TEACHER-STUDENT INTERACTION: THE OVERLOOKED DIMENSION OF INQUIRY-BASED PROFESSIONAL DEVELOPMENT

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Dedication

To my loving partner Richard and wonderful family in Brazil – Adeon (dad), Solângela (mom) and Alandelon (little brother) – for their unconditional love, for always believing in my potential and success, for continuing to support me during my many times of need (emotional as well as financial), and for so unselfishly understanding my reasons for spending so much time away from home in the last five years ever since I decided to leave Brazil (my home country) and come to IU to pursue a doctoral degree in science education. Ironically, as this long and often lonely journey comes to an end, I find myself looking back to its beginning: the night I was at the airport in Sao Paulo alone waiting for my flight to come to the US. My father had written me a letter which I was not supposed to read until I was in the airplane. However, being a stubborn sun, I opened the letter and began to read it in the crowded airport. I remember myself sitting on the floor of the airport with hundreds of people walking by, and feeling profoundly touched and comforted by my fathers' words:

> *"Dear Alan,*
>
> *I know well, and I think that you will too, that certain moments in life will be overwhelmingly defining. Dilemma and unease will take over, leaving us worried and even stunned. But in this moment in which you find yourself in the skies, in a dark, black and daunting vastness, I want to say that I am with you, carried by the great love that I feel for you, and for this reason you may believe that wherever you find yourself, I will be by your side, always looking for you, always certain that you will be well, healthy and protected by God. I will be cheering for your success, because your success will represent my success."*

Reading my fathers' words inevitably leads me to the conclusion that it was my family's love, dedication and support that made my completion of this dissertation possible. For this reason I would like to dedicate this work to these four very special people. I am extremely grateful for having all of them in my life.

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Alandeom W. Oliveira

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Abstract:

This study explores the teacher-student interactional dimension of inquiry-based science instruction. In it, microethnographic and grounded theory analyses are conducted in order to assess the impact of a professional development program designed to enhance in-service elementary teachers' interactional views (i.e., their understandings of inquiry-based social roles and relationships) and discursive practices (i.e., teachers' abilities to interact with student engaged in classroom inquiries) through a combination of expert instruction, immersion in scientific inquiry, and collaborative analysis of video-recorded classroom discourse. A sociolinguistic theoretical perspective on language use is adopted, viewing classroom discourse as comprising multiple linguistic signs (questions, responses, personal pronouns, hedges, backchannels, reactive tokens, directives, figures of speech, parallel repetitions) that convey not only semantic meanings (the literal information being exchanged) but also pragmatic meanings (information about teachers and students' social roles and relationships).

A grounded theory analysis of the professional development activities uncovered a gradual shift in teachers' interactional views from a cognitive, monofunctional and decontextualized perspective to a social, multifunctional and contextualized conception of inquiry-based discourse. Furthermore, teachers developed increased levels of pragmatic awareness, being able to recognize the authoritative interactional functions served by discursive moves such as display questions, cued elicitation, convergent questioning, verbal cloze, affirmation, explicit evaluations of students' responses, verbatim repetitions, IRE triplets, IR couplets, second-person pronouns, "I/you" contrastive pairs, and direct or impolite directives.

A comparative microethnographic analysis of teachers' classroom practices revealed that after participating in the program teachers demonstrated an improved ability to share authority and to transfer expert interactional rights to students by strategically adopting (1) questioning behaviors that were relatively more student-centered, divergent, reflective, and sincere; (2) reactive behaviors that were more neutral and informative; (3) directive behaviors that were more polite, indirect and inclusive; and, (4) poetic behaviors that fostered more involvement. Such ability allowed teachers to establish more symmetric and involved social relationships with students engaged in classroom inquiries.

The above changes in teachers' interactional views and discursive practices are taken as evidence of the effectiveness of an explicit, reflective, authentic and contextualized approach to inquiry-based professional development.

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Chapter 1

THE INTERACTIONAL DIMENSION OF CLASSROOM INQUIRY

Introduction

In a classroom case entitled “who’s teaching whom?,” Lewis & Wagner (2002) narrate the story of Mr. Edmonds, a beginning elementary school teacher who, while implementing a hands-on student-centered science lesson, is confronted by a fourth-grade student more knowledgeable about the topic of simple machines than the teacher himself. Tension and uncertainty are felt in the classroom when Mr. Edmonds, incidentally and out of frustration, relinquishes control of the lesson to the “expert” student, allowing him to stand up and give a ten-minute talk to the rest of the class. This case illustrates well the kind of interactional difficulty commonly experienced by science teachers in inquiry-based instructional settings where teacher-student interactions are often incompatible with expert-novice forms of social activity typically found in classroom settings. Such interactional difficulty indicates that many science teachers are unprepared to effectively cope with the social demands of inquiry teaching. Close examination of descriptions currently used to inform teachers about the nature of inquiry-based science instruction can shed some light on the reasons behind science instructors’ apparent lack of interactional ability.

National documents, teaching methods textbooks and practitioners’ journals provide generalized descriptions of teaching and learning practices considered to be consistent with inquiry-based models of science instruction. In these descriptions, teaching science through inquiry-based methods is typically associated with interactional activities such as guiding and facilitating (NRC, 1996). Teachers and students’ new interactional roles are often described metaphorically, through the use of ill-defined labels that suggest a more symmetric or equal form of social relationship. The student becomes “an active inquirer” (Martin, 2006), whereas the teacher enacts the role of a “fellow investigator” (Lawson, Abraham, & Renner, 1989), “experienced co-learner” (Moscovici & Nelson, 1998), “co-inquirer,” “guide,” or “resource person” (Martin, 2006). The teacher establishes and maintains a delicate balance between being the authority in charge and being a relaxed member of a collaborative group (Krajcik, Czerniak, & Berger, 1999).

Inquiry-based science instruction is also described as a pedagogical approach wherein the teacher asks particular types of questions, including *open-ended* or *divergent questions*, that is, queries that students can answer in multiple ways (Ash, & Kluger-Bell, 1999; Carin, Bass, & Contant, 2005; Cliatt & Shaw, 1985; Colburn, 2000; Martin, 2006; Peters & Stout, 2006); *descriptive questions* that motivate students to describe their work, *challenging questions* that encourage students to explore further, and *connecting questions* that help students link their exploratory work to prior knowledge (Worth & Grollman, 2003). Other two common query types are *probing questions*, requests for students to expand, clarify or justify their own answers, and *redirecting questions*, requests for students to expand, clarify or justify answers provided by other students; both of which tend to occur as *what*, *where*, *when*, *which*, or *why* types of question (Chiappetta & Koballa, 2002). Teachers also ask questions with the pronoun *you* (e.g., “why do *you* think that happened?” rather than “why did that happen?”) to encourage students to focus on their own thinking rather than on trying to reply the right answer (Carin, Bass, & Contant, 2005).

Another distinctive interactional feature of inquiry teaching is the adoption of certain responsive behaviors while reacting to students’ ideas or explanations. The teacher deliberately avoids evaluating the value and accuracy of students’ explanations, and encourages students to ask questions that s/he can answer with simple "yes" or "no" responses (Suchman, 1966). The teacher also *accepts* students' ideas without judging them by repeating and paraphrasing students' responses; *extends* students' inquiries by providing responses that clarify, compare, correct, and apply students' ideas; and *probes* students' ideas by responding with follow-up questions that encourage students to clarify, justify or verify their own ideas (Carin, Bass, & Contant, 2005). Additionally, to promote independent thinking, the teacher *avoids telling* students what to do, and refrain from praising, criticizing, evaluating, rejecting or discouraging students' ideas (Colburn, 2000). Other interactional behaviors commonly associated with inquiry-oriented science teaching include providing helpful suggestions (Lawson, Abraham, & Renner, 1989); modeling scientific behavior and skills, using appropriate scientific terminology, and providing students with appropriate clues and prompts (Ash & Kluger-Bell, 1999); and prompting students to re-examine their work (Worth & Grollman, 2003).

In contrast, inquiry-based science learning is frequently described in terms of student verbal behaviors such as posing questions, proposing and revising explanations and solutions, and using the language of science processes (Ash & Kluger-Bell, 1999). According to the National Science Education Standards (NRC, 2000), inquiry-based science learning is characterized by five essential features: 1) students engage in scientific questions which are posed by the pupils themselves or by their teachers, 2) students provide responses that prioritize evidence, 3) students propose explanations based on evidence, 4) students evaluate their proposed explanations in light of alternative explanations and accepted scientific knowledge, and 5) students communicate and justify their proposed explanations.

In sum, along the teacher-student interactional dimension, inquiry-based teaching is defined as an instructional mode wherein the science teacher relinquishes, at least partially, his/her science expert role by forfeiting interactional rights such as providing the right answers, telling students what to do, and evaluating students' ideas. At the same time, students are encouraged to partially relinquish their science novice roles and take on expert interactional rights such as asking their own questions, and proposing, evaluating and revising their own answers. As both teachers and students start sharing the role of science experts, a more symmetric interactional structure emerges in the classroom, and teacher-student interaction begins to resemble collaboration among peers. Presented below are arguments and research findings that point to limitations in this descriptive account of teaching-student interaction in inquiry-based classroom settings.

The Interactional Complexity of Inquiry Teaching

As pointed out in the previous section, the science education literature commonly used to inform teachers about inquiry-based classroom practices describes the occurrence of more symmetric forms of teacher-student interaction through strategic transfer of expert interactional rights from teachers to students. However, this transfer comes with a cost, the blurring of teachers and students' interactional roles. The increased similarity or proximity of teachers and students' interactional roles has motivated questions such as "who is teaching whom?" (Lewis & Wagner, 2002), accusations of teacher invisibility in the learning-teaching process (Baines & Stanley, 2000) as well as arguments in favor of the superiority of instructional modes that emphasize expert-novice differences (Kirschner, Sweller, & Clark, 2006).

Research studies that have examined teacher-student interactions during the implementation of inquiry-based science instruction suggest that the above descriptions are at best simplistic and over-generalized instructional metaphors that fail to convey the complex interactional expertise that effective inquiry teaching really requires. Crawford (2000) observed that an experienced high school biology teacher actually assumed a myriad of constantly changing interactional roles during the implementation of long-term inquiry projects, including *motivator* (encouraged students to be responsible for their own learning); *diagnostician* (created opportunities for students to express their ideas in order to demonstrate their understandings); *guide* (helped students with design and implementation of investigative strategies); *modeler* (acted in ways that displayed scientific behavior); and *collaborator* (relinquished the role of director, allowing students to assume the role of teachers). Similarly, students assumed varied interactional roles at different moments of inquiry, including more traditional ones such as *learner*, *listener* and *receiver of information* as well as new roles such as *collaborator*, *leader*, *apprentice*, *planner* and even *teacher*.

Current models of inquiry-based instruction encourage teachers to withhold answers from students. However, these models do not provide teachers with specific means or directions to help them handle classroom situations in which the existence of correct answers becomes an interactional issue that needs to be explicitly negotiated with students. Roehrig and Luft (2004) observed that, despite their familiarity with appropriate instructional strategies, beginning secondary teachers' enactment of inquiry science lessons was often constrained by students' expectations that the teachers would provide them with the correct answers. Similarly, a fourth grade teacher in a case study by Keys and Kennedy (1999) identified refraining from answering students' questions directly, and turning students' questions back to them as constituting major challenges during the implementation of inquiry-oriented science instruction.

Furtak (2006) observed that middle school teachers had problems managing student requests for the right answers during inquiry regardless of their teaching experience, discipline background (science or non-science), or professional training. One teacher treated the investigation as a game of “hide the answer,” choosing to enact an “evil scientist” who deliberately withheld answers from the students. In contrast, the most experienced teacher adopted an “anything goes” strategy, encouraging students to share their own answers without evaluating them as being right or wrong. Finally, the least experienced teacher kept rationalizing his teaching strategies to the students. His justification for holding back answers was that students would understand the phenomenon better if they arrived at the answers by themselves.

Several studies have reported pre-service teachers’ frequent difficulties while trying to grasp the form of teacher authority and control required by inquiry instruction. Lotter (2004) observed that secondary teachers often displayed inadequate classroom management (an inability to deal with student misbehavior and reinforce rules) and felt a loss of control during their student teaching experiences. Hayes (2002) described student teachers’ uneasiness at letting go of the authority to control and direct students’ science learning experiences as well as the teachers’ struggles to adopt a form of classroom relationship that was new to them. Similarly, Friedrichsen, Munford and Orgill (2006) described a prospective secondary teacher repeatedly expressing his concerns about not giving away the answers and allowing students to create their own evidence-based explanations.

To summarize, current accounts of the teacher-student interactional dimension of inquiry-based science teaching have been criticized for their inaccuracies and limited descriptive power. Research studies focused on inquiry-based science classrooms provide ample evidence that science teachers need to have higher levels of interactional expertise than what current instructional models can offer. These findings and criticisms highlight the need for the development of instructional models of inquiry science teaching that are more elaborated and firmly grounded in the social realities of science classrooms. Such models are needed in order to better prepare teachers to cope with the difficult and challenging interactional demands of inquiry science teaching.

Teachers' Views of Inquiry Instruction

A growing body of research has shown that the particular ways that teachers view the nature and purposes of inquiry science teaching and learning can have a direct impact on their classroom practices. Roehrig and Luft (2004) described how beginning secondary teachers who viewed inquiry as an effective means for pursuing conceptual understanding encouraged students to pose questions, develop procedures, and conduct analyses. In contrast, teachers who considered inquiry teaching to be primarily a vehicle for learning about science process skills did not encourage students to explain data or discuss underlying science concepts during investigative activities. And, teachers whose primary concern was making sure that students learned the right answers frequently used laboratory sessions to allow students to discover scientific concepts and then lectured them about what should have been observed. Wallace and Kang's (2004) investigation revealed that high school teachers who viewed science teaching primarily as the development of students' conceptual understanding tended to use verification labs, whereas teachers who viewed science teaching as enculturation into scientific practices tended to make extensive use of inquiry-based labs. Lotter, Harwood and Bonner (2007) observed that secondary teachers who perceived inquiry as a thinking process relied mainly on group and teacher-led discussions. In contrast, a teacher who viewed inquiry as a process of data collection and analysis tended to implement hands-on inquiry instruction.

Teachers' perceptions of their students' nature and abilities can also influence the implementation of inquiry-based science teaching methods. Wallace and Kang (2004) found out that high school teachers who considered their students to be lazy and immature or distrusted their students' ability to work independently tended to use demonstrations and cookbook laboratories more often than open-ended, hands-on inquiry activities. Similarly, Crawford (2007) observed that some prospective teachers developed a belief that inquiry-based teaching approaches were inappropriate for their students, who they perceived as being lazy and uninterested. These teachers tended to enact traditional, lecture-driven teaching practices during their field placements. Friedrichsen, Munford and Orgill (2006) described how a prospective teacher who believed that secondary students could not understand or accept the tentative nature of scientific knowledge opted for encouraging students to develop "the correct" scientific explanation based on evidence instead of having students explore and reject alternative explanations. Lotter, Harwood and Bonner (2007) compared the classroom practices of two secondary teachers, one who believed that his students would not be able to inquire without being provided with science content knowledge first, and another teacher who thought that his students could become efficient problem solvers. The former made little use of inquiry-based pedagogy, whereas the latter used inquiry instruction on a daily basis.

In sum, the above studies provide evidence that teachers' implementation of inquiry science teaching can vary widely depending on their personal interpretations of the meaning and purpose of using scientific inquiry as a pedagogical approach as well as their perceptions of students' nature and abilities to engage in this particular teaching-learning mode. In other words, inquiry teaching practice is invariably guided by teachers' personal views or beliefs about the pedagogy and its appropriateness to their classroom contexts. Despite its valuable insights, this literature has two important limitations. First, the available research fails to examine whether or how teachers' interactional views (i.e., teachers' views of social roles and relationships in the inquiry-based science classroom) can influence their use of inquiry-based instructional practices.

Second, research has focused mainly on the views and practices of secondary science teachers, and for the most part ignored how teachers at the elementary level view and practice inquiry-based science instruction. The existence of such gaps in the science education literature seems to be unwarranted given that the research findings described in the previous section indicate that teaching science through inquiry requires a higher level of interactional expertise than previously thought. More elaborate and accurate models of inquiry-based teacher-student interaction should be made available to teachers at both the elementary and secondary levels. A description of how the current study attends to these limitations in the research on inquiry science teaching is presented next.

Research Questions

The present study focuses specifically on the teacher-student interactional dimension of inquiry-based science instruction. Its research design combines microethnography with grounded theory analysis in order to characterize and track changes in elementary teachers' interactional views and performance prior to, during, and subsequent to an inquiry-based professional development program designed to enhance their interpersonal abilities. The analyses as well as the professional development program are multi-focal, centering on seven different aspects of teacher-student interaction (discourse structures, questioning strategies, hedges, recipient practices, directives, personal pronouns and involvement-oriented strategies). Participants in this study are in-service elementary teachers attending the last summer institute of a three-year professional development program called "Scientific Modeling for Inquiring Teachers Network (SMIT'N). The institute was held in the summer of 2007, aimed primarily at enhancing teachers' ability to interact with students through a combination of expert instruction, inquiry immersion experiences and collaborative assessment of interactional performance.

Elementary teachers were interviewed about their interactional views at the beginning and at the end of the summer institute, and video-recorded while implementing what they considered to be inquiry science lessons in their classrooms during the spring and fall semesters of 2007.

The present study is guided by two main research questions related to the impact of the inquiry-based professional development program on elementary teachers' classroom practices and views of classroom inquiry. The two guiding research questions as well as several closely related sub-questions are listed below:

1. How did the institute on teacher-student interaction influence elementary teachers' views of classroom inquiry?
    a. How did teachers view inquiry-base science instruction *prior to* the institute?
    b. How did teachers articulate their views *during* the institute?
    c. How did teachers view inquiry-based science instruction *after* the institute?
2. How did the institute on teacher-student interaction influence inquiry-based science teaching in elementary schools?
    a. How did teachers interact with their students while implementing classroom inquiries *prior to* the institute?
    b. How did teachers interact with their students while implementing classroom inquiries *subsequent to* the institute?

Chapter 2

LITERATURE REVIEW

Introduction

In this chapter, I present a review of scholarly research on teacher-student interaction that can potentially inform professional development efforts aimed at improving in-service elementary teachers' ability to manage verbal exchanges with their students in the context of inquiry-based science instruction. Central to the body of research reviewed here is the theoretical notion that when teachers and students talk, they also interact, that is, they adopt particular interactional positions or roles with respect to each other (Wortham, 1996). For instance, teacher-student interaction tends to be asymmetric in traditional expository classrooms, with teachers taking on high-status interactional roles such as authorities or experts while students occupy lower-status interactional positions such as novices or apprentices. In contrast, as pointed out in Chapter 1, inquiry-based forms of science instruction require that teachers and students adopt more symmetric interactional roles such as "fellow investigators" (Lawson et al, 1989).

Evidence of the adoption of (a)symmetric interactional roles and relationships can be found in the language that teachers and students use to address each other, including their choices of words (e.g., formal vs. colloquial), preferred grammatical structures (e.g., active vs. passive voice), prevalent discourse structures (e.g., who asks questions, who provides answers, and who evaluates answers), and so on. These so-called *linguistic signs* are believed to convey not only semantic meanings (i.e., the literal information being uttered by speakers) but also pragmatic meanings - information about the participants' interactional roles and relationships (Silverstein, 1995).

The present review reflects the above theoretical view of classroom discourse as comprising multiple linguistic signs. Drawing on different areas of research, namely science education and educational linguistics, I examine a variety of linguistics signs revealed by a large number of studies that have examined teacher-student verbal interaction in a range of classroom settings. Overall, the chapter is divided into three main parts. First, attention is given to studies of teacher-student interaction in inquiry-oriented classroom settings. These research studies focus specifically on two linguistic signs: (a) discourse patterns or structures in science classrooms; and (b) teachers' use of student-centered questioning strategies.

The second part of the review is devoted to the examination of research on teacher-student interaction drawn mainly from the field of educational linguistics. More specifically, I review studies that have examined how teachers and students use the following linguistic signs in classroom settings: (a) personal pronouns, (b) hedges, (c) involvement-focused terms or expressions, (d) response tokens, and (e) directives. A distinction is made between linguistic signs found in regulative and instructional talk - two language styles or discourse types commonly used by teachers in classroom settings (Christie, 2000). Regulative discourse refers to language that teachers use to provide directions and identify instructional goals with respect to the content being taught. This type of language tends to be dominant in the opening stages of instruction as well as in instances wherein teachers need to clarify or redefine instructional goals (e.g., to deal with student misbehavior). In contrast, instructional language is about the content being taught (i.e., about the curricular information that students are expected to learn). When teaching is successful these two discourse types tend to converge, and regulative discourse rarely gets foregrounded.

In the third and final part of this review, I examine research on inquiry-based professional development of in-service teachers. Drawing on the science education literature, I review a number of studies containing reports of professional development programs previously offered by science educators while seeking to enhance practicing teachers' abilities to incorporate inquiry-based pedagogy into their classroom practices. Three distinct types of professional development programs are examined: (a) programs that rely primarily on long-term expert instruction and support; (b) scientific research institutes; and (c) collaborative programs.

Review of research related to each particular linguistic sign is followed by a "Discussion" subsection in which I summarize the studies' main findings, discuss their implications, draw connections across studies, and identify areas in need of further research. The chapter then ends with a "Conclusion" section wherein I argue that recent inquiry-based professional development efforts have for the most part neglected the interactional dimension of inquiry-based science instruction, focusing instead on other dimensions such as design of inquiry science lesson, assessment of student learning, and adoption of particular pedagogical strategies. Furthermore, I emphasize the need for science educators to offer inquiry-based professional development opportunities focused specifically on improving teachers' awareness of and ability to employ the many linguistic signs identified in the literature on teacher-student interaction.

Discourse Structures in Science Classrooms

In content-centered classroom settings that emphasize testing practices and knowledge display, teacher-student interactions have been shown to unfold predominantly as Initiation-Response-Evaluation or IRE sequences (Mehan, 1979), a three-part turn-taking structure also known as triadic dialogue (Lemke, 1990). In this authoritarian discursive structure, the teacher makes the initial move by asking a display question (a query aimed at testing students' knowledge rather than a 'genuine' request for information unknown by the teacher). A student then makes the second move by replying with what s/he considers to be the 'right' answer to the teacher's question. Finally, in the third move, the teacher reacts to the student's response by evaluating it as being the correct answer (e.g., by repeating the students' answer or by using affirmative expressions such as "right") or the wrong answer (e.g., by correcting the student's answer). What makes the IRE turn-taking structure authoritative is the fact that the teacher invariably performs the two powerful moves (i.e., asking questions and evaluating students' responses), thus establishing him/herself as a knowledgeable experts while simultaneously assigning students to a subordinate role of respondents. By continuously holding authoritative speaking rights, the teacher is able to control or dominate the classroom discussion, constraining students' contributions, and encouraging students to focus on providing the "right" answers known only by the teacher (as opposed to encouraging students to articulate their own ideas and thoughts).

Studies of teacher-student interaction in inquiry-based science classrooms have revealed the occurrence of discursive patterns other than the authoritative IRE sequences. Wells (1993) investigated classroom exchanges between an elementary teacher and third-graders during an inquiry unit in which students were asked to devise a method for measuring the time to empty a bottle of water without the use of a clock or watch. A discourse analysis of teacher-student interactions revealed that the third move in the triadic dialogue served varied interactional functions. In exchanges in which the teacher tested the students' understandings of the activity's purpose and their knowledge of standard scientific concepts, evaluation was the dominant function of the third move (IRE sequences). In contrast, when the teacher helped students formulate a research problem, consider potential solutions, and reexamine their performed actions, the third move was used not to evaluate the students' responses but rather to provide follow-up information (IRF sequences), that is, to extend students' ideas, highlight the significance of students' contributions, and make connections to other experiences. Furthermore, occurrence of triadic dialogue depended on the manner by which the topic of an episode was introduced and on the status of the information under discussion. IRE sequences tended to occur when the topic was introduced in response to the teacher's questions (i.e., teacher elicitation), and when the discussion was focused on generalized scientific knowledge. However, when the topic under discussion resulted from a student volunteered initiation and the discussion was focused on shared classroom experiences, interactions did not follow the three-part pattern as both the teacher and students tended to offer lengthier contributions to the discussion. Based on these findings, Wells (1993) argues that critical accounts of classroom discourse that have simply accused science teachers of overusing triadic dialogue are mistaken and oversimplified. Triadic dialogue serves important non-evaluative interactional functions that enable teachers and students to co-construct knowledge and meaning from the ideas and experiences contributed by both during classroom discussions.

Wells (1993) makes an important contribution to the science education literature by providing evidence that, in inquiry-based classrooms, the third move of triadic dialogue does not always serve an evaluative function. Teachers and students also use this discursive structure to combine their ideas and experiences into emergent understandings. This alternative use is evident when the teacher uses the third move to provide follow-up rather than evaluate students. These findings are in sharp contrast with previous research on classroom discourse which often accused science teachers of overusing triadic dialogue strictly for evaluative purposes.

Tabak and Baumgartner (2004) analyzed the interactive structure of teacher-student discussions during the implementation of inquiry-based science curricula in classrooms of five different high schools. Working in groups of three, students were asked to use computers to conduct self-directed investigations on the topics of evolution and material engineering while teachers circulated among the groups, occasionally approaching them to have discussions about their ongoing inquiries. A turn-by-turn discourse analysis of teachers and students' interactional positioning revealed the recurrence of three distinct modes of interaction (or participant structures). I-R-E/F (evaluate/follow-up) discourse patterns were observed when the teacher approached students briefly to verify the appropriateness of their procedures or their overall progress (monitor participant structure). This same interactive pattern occurred in longer interactional stretches, while the teacher urged students to adopt standard scientific ways of thinking and acting (mentor participant structure). Within both of these asymmetric interactional organizations, students responded to a question asked by the teacher, who in turn provided an evaluation (when checking the students' knowledge) or some form of feedback (a clarification or suggestion). In contrast, when the teacher adopted the role of a co-investigator, interactions took the form of R-R couplets (referred to as the partner participant structure). In this more symmetric mode of interaction, the teacher did not make bids for information in the initiation slot, instead both the teacher and the student responded to the data at hand. Based on the above findings, Tabak and Baumgartner (2004) argue that the partner participant structure has an important supportive function in inquiry-based learning environments. Within this symmetric interactional structure, not only are students given the opportunity to master or gain proficiency in cultural tools like structure-function reasoning, but they are also encouraged to appropriate such cultural tools (i.e., to develop a sense of personal ownership over them). Appropriation becomes evident when students start using scientific cultural tools strategically to provide support for their position during classroom debates with peers and teachers.

The above study supports Wells' (1993) finding that the third move of the triadic dialogue can also serve non-evaluative functions in inquiry-based classrooms. However, there is an important difference between the two studies. Tabak and Baumgartner (2004) examine inquiry in a computer-based learning environment that does not allow manipulation of variables, whereas Wells (1993) examine inquiry in the context of hands-on experimentation. The discrepant nature of this computer environment might explain the occurrence of R-R couplets, an interactional pattern that is not reported by any other study of classroom discourse. Such couplets may be a unique interactional feature of computer-based learning environments.

Polman (2004) analyzed verbal exchanges between a high school teacher and small groups of students while working on open-ended inquiry project in an earth science class. A discourse analysis revealed that teacher-student interactions tended to have three distinct participant structures: action negotiation dialogues (initiated by a student bid to act, these episodes involved negotiation of groups' subsequent action), student questioning dialogues (initiated by a student bid to ask a question, these episodes were informational or related to classroom procedures and logistics), and action feedback dialogues (initiated by a student's previous actions or report of action, these episode involved provision of feedback on what students have done). Student questioning dialogues were present in significant numbers throughout the project, whereas action negotiation tended to occur more often near the beginning, and action feedback near the end. Although these student-initiated structures were predominant all the way through the project, there were a few instances of teacher lecture (or monologue) while the project was being introduced in the first day, and of IRE sequences during a whole-class brainstorming session on research questions. Polman (2004) argues that the occurrence of these participant structures in project-based learning environments is essential for it enables teachers to assess their students' conceptual and practical understandings and to use this information to guide their subsequent steps. Furthermore, prevalence of teacher-student verbal exchanges that are framed by the students' own questions and actions encourage pupils to maintain a sense of ownership and agency over their inquiry projects.

Polman (2004) provides evidence that inquiry-based instruction allows teachers and students to interact through a variety of structures, ranging from content-oriented patterns such as monologue and IRF to student-initiated sequences. This diversity of interactional patterns is in sharp contrast to traditional classrooms where teacher-student interaction tends to occur strictly through IRF sequences (Lemke, 1990).

Oliveira, Sadler and Suslak (2007a) examined the discursive structure of a verbal exchange between a college professor and a group of three undergraduate students during an inquiry-based classroom activity in which students were asked to explain how a candle works before designing and conducting an experimental investigation. A discourse analysis revealed that professor-student interactions followed varied patterns throughout the verbal exchange. A discussion about the nature of chemical changes unfolded with an IRE format in which the professor continued to evaluate students' responses and suggestions explicitly. In contrast, while challenging the students' explanation for how a candle works the professor actively avoided the use of evaluative linguistic structures by eliminating the third move of the triadic dialogue, a strategy that resulted in a series of IR sequences. Moreover, IRE sequences encouraged students to report in writing what the professor considered to be the appropriate answers, whereas IR sequences encouraged students to articulate and report in writing their own ideas. These findings are taken as evidence that the use of triadic dialogue for evaluative purposes encourages students to rely on instructors' institutional authority whereas use of non-evaluative discursive structures encourages students to become authoritative agents with regard to their emergent scientific explanations.

Like previous research, Oliveira et al (2007a) shows that teacher-student interactions in inquiry-based classrooms do not always follow the conventional IRE interactional patterns. Occurrence of IRE is more likely when the topic under discussion is a standard scientific concept. When teachers and students talk about their ongoing science inquiry experiments, other interactive patterns tend to emerge. Moreover, this is the only research study to give a significant amount of consideration to linguistic signs other than discourse structures in inquiry-based settings (its findings with regard to other linguistic signs will be discussed in following sections).

Mortimer and Scott (2003) explored how high school teachers interacted with their students while implementing a series of science lessons in England. Close analysis and interpretation of the videotaped lessons revealed different interactional patterns. During a whole-class discussion about a hands-on activity involving an electric bell, interactions between a science teacher and year-8 students followed the typical authoritative IRE pattern. The teacher continued to ask closed questions that focused exclusively on the production of heat by the electric bell while students contributed only with single and brief assertions. Students' responses (e.g., "there were sparks") were promptly dismissed if they did not match the one answer that the teacher had in mind. In sharp contrast, interactions between a science teacher and a group of 14-year-old students unfolded as I-R-F-R-F chains. This alternative interactional pattern occurred during a whole-class discussion about the properties of gases, liquids and solids. Rather than evaluating, the teacher used the third move to provide feedback or elaborate on students' answers, encouraging them to continue to articulate their own ideas by offering further responses. This alternative interactional form is considered a strategy that teachers can adopt in order to establish and sustain a more "dialogic" type of classroom discourse in which students' ideas and views are listened to and taken into account.

Although, Mortimer and Scott (2003) adopt a well articulated theoretical framework, their analyses remain superficial and limited to more obvious aspects of teacher-student interaction. Only a few instances of teacher-student interaction are analyzed for the purpose of illustrating their proposed analytical framework. Furthermore, little information is provided about the nature of the science lessons being implemented by the teachers. As a result, it remains unclear whether teacher-student discussions take place in the context of science lessons that are investigative, verification-oriented or merely expository.

Chin (2006) examined the ways of speaking and interacting adopted by two seventh-grade teachers in Singapore while implementing investigative science lessons. Teacher-student interactions took place during whole-class and small-group discussions about the effect of surface area on the dissolving rate of sugar in water, and the effect of organ shape on the amount of gas exchanged during respiration. Analysis of transcribed audio-recordings of classroom talk showed that teacher-student interactions followed a range of patterns including (1) traditional IRF sequences, (2) IRFRF chains in which feedback from the teacher was followed by further responses from the students, and (3) IDRF sequences wherein students discussed among themselves before replying to the initiating question posed by the teacher ("D" stands for student discussion). In the last two interactional patterns, students provided input beyond the initial answer solicited by the teacher. These patterns are taken as evidence of the two teachers' ability to foster dialogic classroom interaction through exploratory or facilitative questioning, that is, series of questions that draw out and extend students' ideas.

Another finding was that the teachers' follow-up moves (the third move of the IRF exchanges) took a variety of forms. Correct responses from students were affirmed by teachers and then followed up with direct instruction (affirmation-instruction); or neutrally accepted and then followed up with related questions that built on previous ones (responsive questioning). In contrast, incorrect student answers were corrected explicitly and followed up with expository comments from the teacher (explicit correction-direct instruction); or simply followed up with a reformulated or challenging question (constructive challenge). These findings are considered evidence that teachers can foster a more thought-provoking classroom discourse and elicit more elaborate and productive student responses by using the F-move of IRF sequences to provide responsive questioning and constructive challenges rather than explicit evaluation and direct instruction.

Consistent with other studies discussed above, Chin (2006) highlights that science teachers can effectively foster a classroom discourse that is more dialogic and reflective by using the third move of the triadic dialogue for purposes other than evaluating the correctness of students' responses. A major strength is of this study is the depth of its analysis which provides a plethora of details about the different forms of teacher feedback as well as their discursive functions. The only weakness of this study is that it provides a relatively limited description of the instructional format of the science lessons being implemented by the two teachers.

Discussion

As Lemke (1990) points out, in content-centered classrooms, teacher-student interactions tend to occur mainly through IRE sequences that allow teachers to maintain an authoritative role (with superordinate speaking rights such as asking questions and evaluating students' responses). At the same time, students are assigned a subordinate interactional status as responders. In contrast, analyses of instructional discourse in inquiry-based science classrooms revealed a range of interactional structures in which students start asking questions while teachers stop evaluating all of students' answers. These alternative interactional structures are important because they allow teachers and students to adopt more symmetric interactional patterns in which authority over the learning of science is shared by both teachers and students. As a result, students are given opportunities to develop and maintain a sense of authority, ownership and agency over their learning experiences (Oliveira et al, 2007a; Polman, 1994; Tabak & Baumgartner, 1994).

Inquiry-based learning contexts allow for relationships, speaker rights and social roles to be continuously negotiated among teachers and students. Instead of interacting strictly through IRE sequences, teacher-student verbal exchanges follow a variety of patterns, including IRF sequences (Chin, 2006; Wells, 1993), R-R couplets (Tabak & Baumgartner, 2004), I-R sequences (Oliveira et al, 2007a), IRFRF sequences (Mortimer & Scott, 2003), and students-initiated sequences (Polman, 2004). Occurrence of these alternative discursive patterns is likely to be influenced by the nature of the inquiry activity being examined (i.e., its contents, goals, format, and relative emphasis on students' prior knowledge, past actions, future actions, or even ongoing data analysis) and by participants' characteristics (grade level, gender, socioeconomic backgrounds, etc). Combined, such contextual factors can explain the wide range of discursive structures observed in inquiry-based classroom settings.

The above studies provide some possible directions for future research. Tabak and Baumgartner' (2004) unique findings (the R-R couplets) indicate that interactional patterns can vary depending on whether inquiry is conducted in a computer-based or hands-on learning environment, an issue that deserves further investigation. Additionally, as Oliveira et al (2007a) point out, too much attention has been paid to discursive structure (i.e., sequence and distribution of interactional moves). More consideration should be given to the pragmatic meanings of other linguistic signs, and to the interplay between these other linguistic signs and particular discourse structures.

Student-Centered Questioning Strategies

Several research studies in the field of science education have examined inquiry-oriented classroom discourse in order to identify the types of questioning strategies frequently adopted by science teachers while implementing student-centered approaches to teaching and learning. Edwards and Mercer (1987) examined teachers' questioning practices while facilitating 'progressive' science lessons in British junior classrooms. These progressive lessons emphasized pupil-centered experiential learning of science, rather than the more traditional transmission of factual knowledge. It was observed that asking questions served as a communicative device by which teachers elicited most student contributions to classroom discourse (e.g., pieces of information, suggestions, etc.). Two different forms of elicitation were frequently utilized by teachers. The first one was called "retrospective elicitation," a form of interaction wherein the teacher asked for a contribution after it had already been spontaneously made by a student. These requests for students to repeat their contributions were interpreted as a strategy that teachers employed to transform students' spontaneous contributions into required responses and to highlight such contributions as being valid and useful (invalid responses were either ignored or discouraged by teachers). In doing so, teachers controlled classroom discourse retrospectively, filtering what information was to become common knowledge (shared or joint understandings) in the classroom. The second form was called "cued elicitation," a type of interaction in which teachers asked a series of questions whose answers they already knew, and at the same time provided students with a high number of clues and prompts by wording their questions in certain ways or by sending non-verbal signals such as intonation, pausing, gestures or body movements. This type of teacher-student interaction resembled a guessing game in which pupils tried to read teachers' communicative signals in order to arrive at the required answers. Teachers' heavy reliance on cued elicitation encouraged students to develop procedural understanding (a grasp of what teachers wanted them to do or say) rather than principled understanding (knowledge of underlying scientific concepts and principles). These findings are considered to be evidence that although some teachers appear to adopt mere facilitative roles (less authoritative and controlling) during discovery activities, they maintain strict control over students' experiences and emerging interpretations through continuous employment of such authoritative eliciting practices.

Edwards and Mercer (1987) provides an extensive, theoretically sound, and sensitive analysis of discursive strategies that authoritative teachers employ to maintain strict control over the process of knowledge construction during science investigations. This study makes an important contribution to the science education literature by describing in detail how seemingly symmetric forms of teacher-student interaction can in fact disguise subtle forms of authority and control on the part of the teacher. It also highlights that the adoption of authoritative interactional positions by science teachers can be less obvious than previously thought.

Konfetta-Menicou and Scaife (2000) compared the types of questions asked by British secondary teachers while implementing two science lessons: a regular, subject-oriented lesson, and an investigative lesson that combined cooperative work with whole-class discussions. Classroom observations revealed that overall teachers asked nine different types of queries that required student to perform increasingly higher levels of mental operations: recalling questions (e.g., “do you remember what a fair test is?”); descriptive questions (e.g., “which tube is the longest?”); procedural questions (*how*-questions such as “how did you measure length?”); evidential questions (e.g., “what is your evidence for this conclusion?”); pattern-recognition questions (e.g., “is there a trend in your results?”); justifying questions (*why*-questions such as “why is this called a fair test?”); *what-if* questions (e.g., “what would be the problem if you tried to measure volume?”); predictive questions (e.g., “based on your previous trials, how long do you think this candle will burn?”); and, concluding questions (e.g., “what did you learn about fair test today?”). Moreover, teachers tended to devote more time to whole-class discussions while implementing investigative science lessons (as compared to subject-oriented lessons), resulting in the occurrence of a much greater number of descriptive questions. This predominance of questions involving lower-level thinking is taken as evidence that simply asking more questions does not make science teachers good facilitators of investigative lessons. Rather than quantity, what really matters is whether teachers ask the types of questions that require students to do more than simply recall previous information or events and to describe appropriate procedures. Teachers need to ask questions that encourage students to think about the conceptual reasons underlying their experimental procedures.

Konfetta-Menicou and Scaife (2000) provide a useful system for classifying and comparing the types of questions that science teachers ask in inquiry-based classroom settings. This study emphasizes that in order to become effective questioners or facilitators, science teachers need to do more than simply ask a high number of questions during inquiry science lessons. Science teachers need to ask questions that encourage their students to perform higher-level thinking and develop deeper conceptual understandings.

Chin (2007) studied the questioning approaches that seventh-grade teachers in Singapore used to stimulate student thinking during a variety of classroom activities, including expository lectures, whole-class and paired discussions, demonstrations, small-group hands-on tasks, and laboratory experiments. Analysis of classroom discourse led to the identification of four productive teacher questioning approaches. The first approach was Socratic questioning which comprised a series of questions used by teachers to scaffold and advance student thinking. Teachers who adopted this approach frequently used techniques such as *pumping* - explicit requests for more information (e.g., "what else?"), neutral feedback (e.g., "mm-hmm") and positive feedback (e.g., "right") to encourage students to further articulate their thoughts or ideas; *reflective toss* – the teacher responded to a student question or statement by posing another question that threw the responsibility of thinking back to the student; and *constructive challenge* – when a student provided an inappropriate answer, the teacher responded by asking a question that encouraged the student to reflect about and reconsider the provided answer (instead of correcting the student directly).

The second questioning approach utilized by teachers was called verbal jigsaw. Teachers who adopted this approach asked questions that focused primarily on eliciting appropriate scientific terminology and key phrases that students needed to be able to express their ideas in a scientific way. Two questioning techniques were associated with this approach: *verbal cloze* – the teacher paused in the middle of a sentence to allow students to complete it (i.e., the teacher created orally a "fill-in-the-blank" type of question); and *association of key words and phrases* – the teacher asked questions that encouraged students to respond with a series of propositional statements that together formed a coherent cognitive framework for a scientific concept involving many technical terms or a sequence of steps (e.g., mitosis).

The third approach adopted by teachers was semantic tapestry, a type of questioning aimed primarily at helping students draw connections among seemingly disparate ideas or concepts. Three questioning strategies were associated with this approach: *multi-pronged questioning* – the teacher posed a series of questions that addressed a single problem from different angles or aspects; *stimulating multi-modal thinking* – the teacher asked questions that encouraged the students to articulate their ideas by making use of multiple resources such as talk, diagrams, written texts, formulas and calculations; and *focusing and zooming* – the teacher asked a series of questions that led students to reflect about an idea at both macroscopic and microscopic level or that alternated between these two focal levels.

The fourth teacher questioning approach was called framing. Teachers who adopted this approach asked questions that served primarily as a frame or structure for a problem, issue or ensuing discussion. Three specific questioning techniques were associated with this approach: *question-based prelude* – the teacher asked questions that served as advance organizers for the information s/he was about to introduce; *question-based outline* – the teacher asked a broad question that provided a macrostructure to a problem or issue, and then followed up with specific sub-questions; and *question-based summary* – the teacher prefaced an expository summary with leading questions.

Chin (2007) considers the above findings as evidence that productive and thought-provoking teacher questioning approaches are both reactive (i.e., the teacher follows up on students contributions and adjusts subsequent questions to students' previous responses) and exploratory (i.e., the teachers' questions are aimed at exploring rather than evaluating students' ideas). In other words, in order to enrich classroom discussions teachers need to be able to ask questions that encourage students to articulate and elaborate their own ideas while simultaneously scaffolding student thinking toward conceptual development.

Drawing on a large body of science education research, Chin (2007) is able to develop one of the most comprehensive and useful frameworks currently available for the examination of teacher questioning practices. This study provides thorough descriptions and illustrations of a large number of specific questioning techniques as well as a detailed analysis of how teachers integrate or combine specific techniques into larger questioning approaches. The only limitation of this study is that it provides relatively limited descriptive accounts of the classroom settings in which teacher-student discourse was captured. As a result, it remains somewhat unclear exactly what type of instructional format is present in the classrooms under examination.

Discussion

Combined the above studies provide an overall characterization of what can be considered effective or productive teacher questioning behavior in science learning environments centered on the student. In such settings, effective teachers avoid authoritative questioning practices such as retroactive and cued elicitation (Edwards & Mercer, 1987); ask questions that foster high-level thinking and encourage students to develop conceptual understanding, including evidential, pattern-recognition, justifying, and concluding questions (Konfetta-Menicou & Scaife, 2000); and adopt questioning approaches that are both reactive and exploratory, including Socratic questioning, verbal jigsaw, semantic tapestry and framing (Chin, 2007). Furthermore, effective teachers shift from an evaluative questioning mode in which questions are asked simply to evaluate students' ideas or test their knowledge to an exploratory questioning mode that prompts pupils to articulate, elaborate and extend their own understandings related to science.

The main implication of the above characterization is that in order to become effective facilitators of inquiry-based science instruction teachers need to stop asking evaluative questions focused mainly on the promotion of student mastery of science content. Furthermore, science teachers need to start making skillful use of student-centered questioning practices that encourage pupils to construct well-developed and elaborated scientific ideas and understandings. Such changes in questioning practices are likely to lead to the emergence of a learning environment where both teachers and students share control over the process of construction of common knowledge (Edwards & Mercer, 1987).

Teachers and Students' Use of Personal Pronouns

Another important aspect of teacher-student interaction is the use of personal pronouns as a means to create and transform classroom relationships. Several studies in both educational linguistics and science education have examined how teachers and students' employ personal pronouns to sketch out certain types of interactional structures or social contexts in the classroom. A recurring theme in this research is that, while some pronouns have the effect of distancing or separating teachers and students into different social groups, others seem to promote closeness or solidarity (Brown & Gilman, 1960). The term "solidarity" is used in reference to pronoun use aimed at creating the impression of a common ground or social group, thus generating a sense of camaraderie between teachers and students. Such interactional patterns of pronoun use are described and illustrated below.

Two studies have examined teachers' use of personal pronouns while implementing inquiry-based science instruction in their classrooms. In the first study, Tabak and Baumgartner (2004) analyzed discussions between a science teacher and three high school students during an inquiry-based unit on evolution and found out that the teacher's choice of personal pronouns in symmetric and asymmetric participant structures differed significantly. While giving directions, the teacher used the exclusive pronoun *you*, indicating that she had adopted the interactional position of an outside authority and established an asymmetric teacher-student relationship. In sharp contrast, the teacher's use of inclusive first-person pronouns (*I* and *we*) was interpreted as an indication that she had positioned herself as a co-investigator, and thus established a symmetric teacher-student relationship.

Tabak and Baumgartner (2004) pay only minor attention to the ways that the teacher and students use pronouns, focusing instead on prevalent discourse structures (i.e., teacher and students' performance of particular interactional moves). The analysis of how the teacher uses personal pronouns during the inquiry-based instructional unit seems to be based on mere superficial inspection of transcripts rather than a more systematic exploration of pronoun use.

In the second study, Oliveira et al (2007a) examined audio-recordings of a discussion between an experienced professor and a group of three college students during an inquiry-based classroom activity in which the students were asked to explain how a candle works. A discursive analysis of the audiotapes revealed that the professor used first- and second-person pronouns strategically. First, through contrastive juxtaposition of the pronoun *I* to the students' *we*, the professor divided himself and the students into two distinct social groups, hence establishing an interactional organization early in the discussion. Second, by ceasing the use of first- and second-person pronouns altogether the professor was able to position himself as a science authority in order to dismiss students' conception of bee puke as a potential source of candle wax. Third, the professor used the exclusive form of the pronoun *we* to justify a sudden shift into an authoritative interactional position in terms of his membership to a community of science experts. Fourth, the professor employed the inclusive *we* while referring to a previous activity in order to gradually blur his distinctive interactional category and momentarily shift into the perspective of a novice. And fifth, through systematic opposition of *you* and *I*, the professor was able to once again separate himself from the students and adopt an authoritative interactional position that allowed him to mount a challenge to the students' ideas.

Oliveira et al (2007a) criticize Tabak and Baumgartner' (2004) generalization that first-person pronouns are invariably inclusive, arguing that it fails to take into account the fact that English speakers commonly make use of an exclusive form of the pronoun *we* as well as the inclusive one. Each of theses two forms of the pronoun *we* points to a different interactional structure. In the former, the teacher associates himself with a group of outside experts that excludes the students, whereas the latter constitutes a solidarity-building strategy that the teacher adopts in order to associate him/herself with students.

Several educational linguistic studies have examined how teachers use personal pronouns in a variety of classroom settings, including mathematics and history classes. Rounds (1987a) examined the use of personal pronouns by native and nonnative English-speaking instructors while teaching undergraduate mathematics classes. A characterization of what constitutes successful or communicatively competent teaching discourse was produced based on quantitative and qualitative analyses of a corpus of five 50-minute videotapes. Although all instructors adopted the same "chalk and talk," monologic approach to teaching, some were judged to perform more successfully than others. The more successful instructors tended to use the pronominal form *we* more frequently than their less successful counterparts. The pronoun *we* was used 62-65% of the time (approximately three times more frequently than *I* or *you*) by successful instructors, whereas less successful instructors used *we* only 40-50% of the time (less than twice as often as *I* or *you*). Throughout their classes, the instructors used the plural pronoun *we* rather than *I*, *you* or *one* to refer to themselves (e.g., "In the last class, *we* said that…"), to refer to their students (e.g., "In today's class, *we* will solve the exercises on page 10"), and to refer to mathematics experts in general ("*We* consider equations to be…"). These findings are interpreted as an indication that the occurrence of successful teaching discourse is contingent upon instructors' ability to use the solidarity-building pronoun *we* to establish and maintain a cooperative and consensual interactional atmosphere in the classroom, that is, a sense that teachers and students are working together toward a common goal.

In a more expanded qualitative analysis of the same corpus of videotapes, Rounds (1987b) showed that mathematics instructors avoided explicit third-person references by employing the pronouns *I*, *you* and the exclusive *we*. While naming or defining particular mathematical processes the instructors sometimes used *I* instead of *mathematicians* or *they* (e.g., "*I* call this a square root"), thus claiming authority over specialized terminology. In other moments, instructors used the pronoun *we* to associate himself with expert mathematicians, at the same time excluding the students (e.g., "*We* call this a square root"). Additionally, the pronoun *you* was often used in place of the indefinite *one* while explaining general mathematical procedures (e.g., "In this type of operation, *you* need to subtract digit by digit"). This active avoidance of overt third-person references was interpreted as a strategy aimed at blurring status differences between mathematicians, students, and teachers in order to prevent the emergence of authoritarian social atmosphere in the classroom, that is, the impression that students' actions were being dictated by the teacher or outside experts.

Rounds' (1987a) first study provides a more limited account of instructors' use of personal pronouns, focusing mainly on reporting their relative frequencies. The first study examines several interactional dimensions simultaneously, personal pronouns being just one of them. In contrast, Rounds' (1987b) second study is more comprehensive, being focused exclusively on how mathematics instructors employ personal pronouns. In addition to reporting statistical results, the second study also provides a detailed qualitative examination of how instructors skillfully use *we* as a replacement for other personal pronouns.

Influenced by Rounds' (1987a; 1987b) findings, Fortanet (2004) explored the frequency in use, referents and discourse functions of the pronoun "we" in university lectures. This exploration included a large and multidisciplinary corpus of transcribed academic speech, including lectures in the fields of biological, physical and social sciences, engineering and education. A discourse analysis revealed that the pronoun *we* was used half as many times as *I* and *you*. These results, which are the opposite of those obtained by Rounds fifteen years earlier, were interpreted as an indication of a new tendency in academic discourse toward the acceptance of the pronoun *I*. A second finding was that instructors often used *we* in reference to self and students (inclusive *we*), self and outside people (exclusive *we*), self (as a replacement for *I*), students (as a replacement for *you*), outsiders (as a replacement for *they*) and a generalized person (as a replacement for the indefinite *you* or *one)*. This finding is presented as evidence of the inherent vagueness in meaning of the pronoun *we*. A third finding was that instructors used the inclusive *we* 62% of the time whereas the exclusive *we* was used only 38% of the time. This result was interpreted as evidence that, in academic discourse, *we* is mainly used to build cooperation with students rather than to create an interactional distance between teachers and students. Another finding was that instructors also used *we* to guide students' interpretation of the lecture, course and discipline. By using *we*, instructors avoided presenting themselves as authoritarian experts.

Unlike Rounds, Fortanet (2004) examined a variety of classroom settings such as lectures, colloquia and study groups in the field of mathematics as well as other disciplines. It is likely that such contextual variations might have impacted the instructors' pronominal choices, thus suggesting that the use of personal pronouns in classroom settings can vary depending upon the discipline being taught and the type of instructional activity being implemented. Fortanet's (2004) failed attempt to replicate Rounds previous results serves as a word of caution against reducing successful teaching to skillful use of the pronoun *we*.

Rowland (1999) studied how elementary teachers and students used personal pronouns while engaged in mathematical discussions. A discourse analysis revealed that students often used the pronouns *it* and *you* to make vague reference to mathematical entities and relationships while stating general procedures or standard algorithms (e.g., "*you* square *it* every time"). Pupils used the pronoun *you* vaguely, not to denote the teacher, but as a replacement for the more formal and indefinite pronoun *one*. In other words, pupils employed *you* as a verbal cue to signal that a mathematical generalization was being offered, not to address teacher directly. Furthermore, vague use of the pronoun *it* in reference to mathematical entities and relationships enabled students to articulate their thinking or reasoning despite their lack of more advanced mathematical terminology. In contrast, teachers frequently used the pronoun *we* in ways that excluded the students (e.g., "how did *we* say you had to do square roots?"). In doing so, teachers associated themselves with an anonymous community of experts to add authority to their requests for students to conform to standard mathematical practices. This exclusive use of *we* was interpreted as a strategy that teachers utilized to urge students to acquire the "correct way" of doing things without voicing opposition or attempting to make sense of the situation at hand.

By doing so, the teachers were considered to be giving priority to conformity over comprehension.

While other studies focus exclusively on teachers' use personal pronouns, Rowland (1999) also provides an in-depth and sensitive analysis of how pupils employ pronominal forms in classroom discourse. The reported findings seem to have a great informative value for teachers. An increased awareness of vagueness and ambiguity in students' use of pronouns can potentially enable teachers to develop more appropriate questioning skills focused specifically on helping students better articulate their generalized statements. For instance, teachers can prompt students to clarify what concepts or relationships are referred to when they use the pronoun *it*.

Wortham (1996) examined how Mr. Smith and Mrs. Bailey, two teachers who did not get along well, used personal pronouns while co-facilitating a whole-class discussion in a ninth-grade history class. Whereas Mr. Smith often used *we* to associate himself to the other teacher, Mrs. Bailey tended to use *he* or *you* and *I* to separate herself from Mr. Smith. As the discussion unfolded, Mrs. Bailey was able to systematically exclude Mr. Smith through continuous use of third-person pronouns (*he*, *him* and *his*) and at the same time affiliate herself with the students by using the pronoun *we*. As a result, the discussion started to resemble a conversation about Mr. Smith who was implicitly assigned to the role of a tyrant. These findings are considered as evidence that third person pronouns like *he* and *she* can be strategically used to prevent the person referred to from taking on the role of interlocutor.

Wortham (1992) analyzed teachers' use of personal pronouns during a second discussion in the same ninth-grade history class wherein Mr. Smith and Mrs. Bailey defended the Spartan political system while their students attacked it. In the beginning of the discussion, the two teachers used the pronouns *we* and *they*, placing themselves and the students in the same social group in direct opposition to Spartans. However, as the discussion progressed, the teachers started using *we* and *you*, a pronoun opposition that led to the emergence of a new interactional structure in which teachers cast themselves as members of an authority social group from which students were excluded. These findings are considered evidence that systematic use of the personal pronoun opposition *we*: *you* leads to an interactional organization in which the addressee is excluded from the speaker's social group.

Wortham (1992; 1996) conducted the most systematic studies of personal pronouns, offering a solid theoretical framework through which to examine how speakers use pronouns to organize and transform their social relationships while engaged in classroom discussions. Rather than simply quantifying the use of pronoun in classroom settings, Wortham adopts a mapping technique that allows him to examine in detail how pronominal forms used by teachers and students continuously (re)constitute the interactional framework of a communicative event.

Discussion

Research on teachers' use of personal pronouns has revealed several trends. First, there is a growing amount of evidence indicating that successful teaching can be contingent on teachers' ability to employ the inclusive "we" to promote solidarity with students (Oliveira et al, 2007a; Rounds, 1987a; Wortham, 1996). Nonetheless, it seems hasty to reduce successful teaching to such an interactional ability for there is also evidence that instructors may have started to use the pronoun *I* with an increased frequency in the last few years (Fortanet, 2004). A second trend is that teachers tend to adopt an authoritative interactional position and exclude students when they use pronouns such as the exclusive *we* (Fortanet, 2004), third-person pronouns in reference to an outside community of experts (Rounds, 1987b) or to particular classroom participants (Wortham, 1996), and contrastive pairs such as *I*/*you* (Rounds, 1987a) and *we*/*you* (Wortham, 1992). Alternatively, teachers can adopt an authoritative interactional position by avoiding the use of personal pronouns altogether (Oliveira et al, 2007a).

Although a few studies have already examined the use of personal pronouns in inquiry-based science classrooms, their focus has been limited to teachers' use of *I*/*you* contrastive pairs and the pronoun *we*. As pointed out by Oliveira et al (2007a), some studies have equated the establishment of symmetric teacher-student relationship to the use of *we*, an oversimplification that ignores the fact that the pronominal form *we* can be used to exclude students, thus leading to asymmetric teacher-student relationships. Further research is needed in order to clarify exactly how personal pronouns can be used by science teachers as an interactional resource to establish and maintain the more symmetric forms of teacher-student relationship required by inquiry-based instruction.

Hedging in Classroom Settings

An aspect of teacher-student interaction that has remained largely unexplored in both educational linguistic and science education research is the use of hedges (Lakoff, 1972), that is, words, expressions and intonations that are characteristically vague, indirect or unclear (e.g., *about*, *maybe*, *probably*, etc.). The crucial effect of hedges is that by being vague the speaker becomes less committed to the truth or falsity of a statement, thus having less at stake in the propositional contents being uttered. In this section, I review the few studies that have examined how teachers and students use hedges in classroom settings. These studies adopt an interactional approach to the concept of vagueness in classroom discourse, viewing hedges not as defects or deviations from precise and clear language but as interactional resources that teachers and students draw upon strategically when faced with communicative tasks.

Oliveira et al (2007a) was the only study to examine the use of hedges in an inquiry-based science classroom. The setting was a discussion between a college professor and three undergraduate students about how a candle works. A discourse analysis of professor-student interactions revealed that students employed several forms of hedges – they used uncertainty adverbs (e.g., "maybe"), juxtaposed alternative ideas (e.g., honey vs. wax as components of "bee puke"), added tag questions to their declarative statements (e.g., "right?"), and used rising intonations while responding to the professor's questions (e.g., "it was a chemical change?"). By using these discursive strategies, students were able to create uncertainty and signal weak commitment to the referential contents of their utterances. On the other hand, the professor often made vague evaluative comments about students' ideas, repaired his turn in progress (by inserting the exclusive *we* and indirect quote markers, e.g., "you said that…"), used the adverb *maybe* and prolonged "hu:m." While the last two forms of hedging were used to construct uncertainty, the other forms constituted strategies to avoid giving more explicit evaluations of students' work. These findings are interpreted as evidence of the value of hedges as an interactional resource that can be skillfully used by teachers as well as students in order to avoid explicitly evaluating or committing to the correctness of particular utterances and ideas.

The study conducted by Oliveira et al (2007a) highlights that skillful inquiry-based science teaching requires an awareness of and ability to use hedges. By strategically hedging, teachers can steer their interactions with students away from the strictly evaluative focus that exists in most classrooms, thus encouraging students to articulate and explore their own ideas and thoughts rather than continue to fish for the right answers.

Fortanet (2004) described the use of two different forms of hedges in university lectures. First, lecturers often quoted or cited anonymous speakers. In reporting opinions expressed by some unknown others and by using words that were not necessarily accurate or even literally said by them, lecturers avoided committing to the truth of the quoted material. Second, lecturers frequently shifted from the singular pronoun *I* to the plural *we* (e.g., “in *my* field work, *we* visited different schools”). These shifts were considered to be a strategy that lecturers adopted in order to protect themselves from questions and opinions of members of the audience. By replacing *I* for *we* (also known as the “royal *we*”), lecturers presented themselves publicly as representatives of a larger social group who shared the same views or opinions rather than individuals expressing personal ideas, views or opinions.

Fortanet (2004) gives only minor consideration to lecturers’ use of hedging strategies; the main focus of the study is actually on how lecturers employ the pronoun “we” to build cooperation or solidarity with their audiences. No theoretical definition is provided for hedges and their use is analyzed only superficially. As a result, the study provides only limited and unelaborated descriptions of hedging strategies in university lectures. Nonetheless, the reported findings seem consist with other studies reviewed in this section.

Rowland (2000) examined how pupils in the 9 to 12 age range used hedges while engaged in an investigative mathematical task that encouraged them to predict and generalize. Pupils worked in pairs on combinatorial problems (e.g., to determine the number of ways that two positive integers can be made add up to ten) and interacted with the researcher who adopted a teacher-like questioning behavior. A discourse analysis revealed that, when asked to predict the number of possible combinations, students frequently used different types of hedges. The first type was plausibility shields (e.g., “I think,” “maybe,” “probably,” and “possibly”), that is, expressions that indicated that pupils had some doubt about the validity of their responses, and for this reason were not willing to fully commit to their truth. The second category was composed of rounders (e.g., “about,” “around,” “approximately,” and “basically”), that is, expressions that students used to insert vagueness and withhold full commitment to their quantitative answers. The third type of hedges was called adaptors (e.g., “a little bit,” “somewhat,” and “fairly”), terms that students used to attach vagueness or ambiguity to particular nouns, verbs or adjectives. And, the last type was maxim hedges (e.g., “well”), expressions that students used to signal that the response they were about to offer did not entirely meet the demands of teachers’ questions. In other words, by prefacing their responses with words like *well*, students’ acknowledged upfront a certain level of inadequacy in their suggested answers. These hedges were considered to serve a self-protective function, that is, shields that students frequently employed as a safeguard against being accused of being wrong in classroom settings.

In a separate analysis, Rowland (2000) examined how hedges were used by primary and secondary school mathematics teachers. This analysis revealed that teachers frequently used attributions shields (e.g., “Ann says that 70 can be divided by 6. What do other people think?”), that is, expressions in which teachers explicitly attributed authorship of ideas or responses to individual students. This was considered a pedagogical strategy that teachers skillfully used to distance themselves from students’ propositions in order to remain neutral and avoid giving an explicit evaluation of students’ responses.

Unlike other studies, Rowland (2000) conducts an extensive amount of research focused exclusively on the interactional functions of hedging in classroom discourse. Its strengths include a solid theoretical framework, in-depth analyses, and extensive consideration of pedagogical implications of reported findings. Although hedges are analyzed in the context of investigative mathematical tasks, these tasks seem to have a high degree of similarity with inquiry-based science activities, which also are investigative and require students to make predictions and generalizations. Therefore, it seems reasonable to expect hedges to be used in similar ways in inquiry-based science classrooms.

Discussion

The studies reviewed above highlight that hedges are an important component of skillful teaching discourse. Through strategic employment of hedges, teachers can avoid giving explicit evaluations of students work (Oliveira et al, 2007a), and distance themselves from students' propositions (Rowland, 2000). Such interactional skills are very important for inquiry-based science teaching, an educational approach that requires teacher-student interactions to shift from an evaluative focus to an exploratory one. Moving away from an evaluative focus can be difficult a task for teachers whose efforts are likely to be resisted by students who are used to simply being told the right answers. Oliveira et al (2007a) describe students actively countering the professor's discursive strategies by trying to elicit evaluations from him. Nonetheless, the professor is able to successfully deal with this resistance from students through strategic use of hedges and direct quotations (attribution shields) to avoid giving away the solicited evaluations and remain neutral.

Rowland's (2000) study points out that hedging constitutes an important aspect of student communicative behavior during mathematical tasks that require pupils to predict and generalize. An interesting finding of this study is that students sometimes use approximators in ways that render their mathematical predictions and generalizations almost unfalsifiable. For instance, a statement such as "there are *about* ten beans in the jar" cannot be refuted whether an actual count reveals ten beans or not. Considering that generalizations and predictions are an integral part of inquiry-based science learning, it can be argued that science teachers also need to pay close attention to how their students perform hedges and whether their students' performance can be considered scientific or not. None of the reviewed studies address this particular issue.

Involvement in Classroom Discourse

Previous examinations of classroom discourse have revealed that effective teachers often resort to a variety of linguistic devices in order to foster student interactional involvement or engagement. In this research, the term "involvement" is commonly utilized in reference to language use that is more focused on participants' immediate surroundings, personal feelings and manners of talk than with clear, explicit and detached transmission of content or information (Tannen, 1985). Highly-involved discourse can move hearers and trigger emotional responses on them, being marked by communicative strategies commonly encountered in everyday, casual conversations such as deictic modifiers (e.g., *that* book), emphatic particles (e.g., *just*, *really*) and fragmentation (e.g., frequent pauses, false starts, repairs, backtracks, fillers, and parallel repetitions). Similarly, the term "engagement" is used in reference to language that participants use to acknowledge, connect to and focus the attention of an audience (Hyland, 2005). Below, I review several studies of involvement and engagement in classroom talk.

Oliveira et al (2007a) identified the use of parallel repetitions by a college professor during implementation of an inquiry-based science lesson. While interacting with the students, the professor would repeat his negative assessment of students' work multiple times in a row (e.g., "I don't think you've explained it," "you haven't told me," and "you haven't answered the question"). This repetitive and seemingly redundant discursive pattern, often found within single utterances, was considered to be a strategy by which the professor effectively drew students' attention to his negative evaluation of their work. In doing so, the professor was able to intensify the strength of his negative assessment and encourage students to become more emotionally involved in the discussion.

In showing how the professor uses parallel repetitions to encourage the three students to become emotionally involved, Oliveira et al (2007a) provides evidence that teachers and students' collaborative efforts during scientific inquiry involve not only logical processes of cognition but also emotional feelings. This study makes a significant contribution to the literature on science classroom discourse, a field where the affective dimension of teacher-student interaction has been left largely unattended.

Some of the teacher-student discursive patterns already discussed in previous sections were also considered involvement-focused strategies. Rowland (2000) argued that primary and secondary school teachers' used attribution shields to encourage students to participate in classroom discussions. By providing responses such as "so-and-so said this… what do you think?" teachers were able to sustain discussions about particular mathematical problems. Teachers' invitations for students to evaluate the validity of their peers' proposed ideas and to share their own opinions and thoughts were considered a pedagogical strategy aimed at keeping students engaged or involved in teacher-student interactions. Likewise, Fortanet (2004) considered speakers' frequent use of the inclusive *we* in university lectures to be a discursive strategy aimed at involving the audience. Speakers frequently replaced *they* for *we* while referring to larger groups (e.g., "humans are social beings, so *we* need to interact with others"), and *I* for *we* while referring to communicative activities that only the speaker would be performing (e.g., "today, *we* will be talking about chemical reactions"). In both cases, the speaker sought to involve the audience in what s/he was doing or saying through strategic use of the inclusive *we*.

Neither Fortanet (2004) nor Rowland (2000) provides an explicit definition for what they call involvement. Moreover, rather than conducting more systematic discourse analyses, the two studies merely make occasional references to the notion of involvement, entertaining the hypothesis that the interactional patterns being reported can potentially serve to encourage students to become more involved in classroom activity.

Nunn (1996) studied discourse-related teaching techniques utilized by effective university faculty members to encourage students to participate in classroom discussions. Correlation analyses of surveys and video-recordings of classroom interactions revealed statistically significant relationships between amount of student participation and faculty members' use of discursive techniques such as asking questions, and using students' names. Furthermore, asking rhetorical questions and making humorous comments were also included among faculty members' most frequently used teaching techniques to encourage student participation. These findings were considered as evidence of the effectiveness of these teaching techniques as encouragers of student participation and engagement in classroom discussions.

Unlike other studies reviewed in this section, Nunn (1996) does not adopt a linguistic theoretical framework based on the notion of interactional involvement or engagement. Instead, Nunn (1996) sets out to determine the frequency and efficiency of use of a set of teaching techniques previously identified by research in the field of education. In other words, classroom interaction is approached from an educational perspective rather than a linguistic one. Nonetheless, most of the techniques used by teachers to elicit student participation are considered involved-focused communicative strategies in the linguistic research, thus suggesting a high degree of alignment between the two perspectives.

Simpson and Mendis (2003) identified what idioms occurred and what discursive functions they served in a variety of interactive and monologic academic settings, including lectures, dissertation defenses, study group sessions, and office-hour interactions. Idioms were defined as engaging, casual and memorable expressions that were relatively fixed (i.e., formed by a more or less fixed sequence of words), semantically opaque (their composite meanings were not apparent from the combined meanings of individual constituent words), and institutionalized (accepted as a convention by a wider discourse community). Among the idioms most frequently utilized in academic speech were "bottom line," "the big picture," "come into play," "down the line," "what the heck," "flip side of the same coin," "on the right track," "knee-jerk," "hand in hand," "right off the bat," "carrot and stick," "draw the line," "on target," "thumbs up," "out the door," "rule of thumb," "take at face value," "beat to death," "put the heat on," "a ballpark idea," "full-fledged," "get a handle on," "nitty-gritty," "on the same page," "ring a bell," "take a stab at it," "take someone's word for it," and several others. The most salient discourse functions served by idioms in academic discourse included evaluation (e.g., "the drawing is *out of whack*"); description (e.g., "economy and politics go *hand in hand*"); paraphrase, which involved the juxtaposition of a formal academic word or phrase with a more colloquial synonymous expression (e.g., "in science, measuring is *a dime a dozen*, it is performed all the time"); emphasis, which often involved repetition of a particular idiom (e.g., "it's like *the kitchen sink*, we throw everything in but *the kitchen sink* and then take an average"); collaboration, expressions that speakers used repeatedly to create solidarity with hearers while expressing shared ideas or views (e.g., "the press has *put the heat on* politicians, we've seen the *heat being put on* them"); and metalanguage, expressions that signaled a new direction or the closing of a discussion (e.g., "on that note," "go off on a tangent," and "cut to the chase"). These findings are considered to constitute evidence that the occurrence of idioms is not limited to strictly informal and interactive contexts as commonly assumed. Instead, idioms lend themselves to wide range of discursive functions even in more formal and monologic academic settings.

Simpson and Mendis' (2003) study has several strengths, including a clear and well-elaborated definition for idioms, a clear research objective (i.e., to gather evidence that idioms are also pervasively used in institutional settings), and a thorough discussion of pedagogical implications of reported findings. The only limitation of this study is that it provides a relatively poor description of educational features present in the classroom settings under examination.

Csomay (2006) investigated the extent to which university class sessions (both large lectures and small seminars) shared the same linguistic features commonly found in casual, face-to-face conversations. Statistical analyses indicated that, like face-to-face conversations, university classroom talk had a number of linguistic features that suggested a high level of personal involvement. The following linguistic features occurred with similar frequencies in both conversations and classroom sessions: the present tense; private verbs (e.g., *think*, *feel*); 'DO' as pro-verb, that is, as a replacement for another verb to provide a more general reference, (e.g., "she can *do* it."); the pronoun 'IT' as an economical way of referring to things; first and second person pronouns; contractions (e.g., "he's…"); and 'THAT' deletions (e.g., "I think [*that*] you are…"). Other conversational features were found to be even more frequent in class sessions than in casual conversations: demonstrative pronouns (e.g., "could you write *this* down?"); 'BE' as copula, that is, as a mere link or connection between two different things (e.g., "he *is* well-read"); and WH-questions (e.g., "*why* did that happen?"). These findings were taken as evidence that university classroom talk resembles casual, face-to-face conversation in terms of personal involvement. Like conversations, classroom discourse is highly involved, that is, to a high degree focused on immediate contextual circumstances and on participants' attitudes and feelings.

Although based on a solid theoretical framework, Csomay's (2006) study seems to have been designed in a somewhat problematic way. First, the study seems to be framed by a very vague research objective which is to determine whether academic speech is as involved as casual conversations or as detached as academic writing. Second, data is collected across a very wide range of classroom settings, including lectures and seminars in six different universities. No consideration is given to variations in classroom contexts, instructional activities, disciplines, or topics. And, third, no potential implications for the reported findings are offered. Overall, the study seems to provide a generalized description of academic speech, offering a very limited amount of actual discourse analysis.

Discussion

The above literature provides ample evidence that the language used by effective teachers serves interactional functions other than simply inform students. Even in monologic instructional activities such as lectures, effective teachers speak in ways that encourage students to become emotionally involved or engaged in classroom activity. These teachers frequently foster student involvement through the adoption of communicative strategies such as parallel repetitions (Oliveira et al, 2007a); attribution shields (Rowland, 2000); rhetorical questions, students' names, and humorous comments (Nunn, 1996); idiomatic expressions (Simpson & Mendis, 2003); and conversational devices (Csomay, 2006). Such findings highlight that effective teaching practice is not limited to detached transmission of curricular information or content, even in teacher-centered instructional activities.

While the majority of the studies reviewed above focus on university lectures, Oliveira et al (2007a) and Rowland (2000) examine how instructors use involvement-focused communicative practices during the implementation of investigative classroom activities. The reported findings indicate that involved language is also used by skillful teachers in inquiry-based settings. However, none of the two studies conducts a more extensive analysis of teachers' use of involvement-focused language, instead giving it only minor consideration. More systematic and extensive research is needed in order to clarify the function(s) and relative importance of involved discourse in investigative instructional settings.

Teachers and Students' Reactive Behaviors

Research on classroom discourse has indicated that recipient behavior (reactive tokens that hearers use while a speaker is holding the discussion floor to inform him/her whether the message is being transmitted successfully or not) is an important aspect of teacher-student interaction. In everyday conversations, reactive tokens are mostly in the form of backchannels (facial gestures, nods, smiles, nonverbal vocalizations such as "mm" and "uhuh," or words such as "yeah" and "okay") that serve to simply maintain an open channel of communication between the hearer and the speaker, and to display active listenership (Schegloff, 1982; Yngve, 1970). Although backchannels also occur in classrooms, recipient behavior in these settings tend to be more than minimal in nature, that is, they serve communicative purposes other than to simply demonstrate attentiveness.

Waring (2002) examined the verbal resources that a university professor and nine students deployed to display their understandings to each other (i.e., their recipient behaviors) during a series of graduate level seminar discussions. A discursive analysis of transcribed audio-recordings of whole-class discussions revealed that, while deliberating ideas, participants often reacted by offering candidate understandings that served to check, clarify, expose and substantiate meanings and positions. Three different recipient practices were frequently utilized by participants to offer candidate understandings. The first one was *reformulating*, expressions such as “what you are saying is that…” or “so, you are arguing that…” used primarily by a third-party recipient to make explicit what was implicit in previous talk in order to resolve disagreements between other participants. The second recipient practice was *extending*, a discursive move in which the listener verbalized the gist of prior talk, provided an analogy, or offered an illustrative example in order to stretch a prior a explication or assertion into full development, thus moving the discussion into a higher level of specificity, clarity and thoroughness. And, the third recipient practice was *jargonizing*, short and structurally simple moves in which participants offered a technical way of expressing an idea, thus leading to the crystallization of prior talk into discipline-specific terminology. These recipient practices were referred to as *substantive recipiency* and were considered to be multifunctional discursive devices. In offering constant understanding checking, not only did participants signal their attentiveness but they also fostered collaboration and affiliativeness with other academic participants.

Waring (2002) provides an extensive and systematic examination of recipient behavior in classroom settings. This study makes an important contribution to research on classroom discourse by highlighting the multifunctional nature of teachers and students’ acts of listening. More specifically, it illustrates in a clear manner how teachers can accomplish more than simply signal attentiveness or listenership to their students by offering candidate understandings while reacting to pupils’ contributions to classroom discourse.

Oliveira et al (2007a) examined the recipient practices displayed by college students and a professor during a discussion about how a candle works. A discourse analysis showed that while students often made use of backchannels to signal attentive listenership, the professor's recipient practice varied throughout the discussion. First, the professor used backchannels (e.g., "okay") to avoid answering students' questions directly, and at the same time encouraged students to express their own ideas. And second, the professor offered candidate understandings (i.e., he offered tentative interpretations of students' statements or utterances, e.g., "so what you are saying is that the wax melts and then runs to the bottom of the candle?") while discussing and challenging the ideas that the students had written down on a laboratory worksheet. Furthermore, the professor's recipient practice was more than minimal (i.e., not limited to keeping an open channel of communication) when he tried to help students to clarify and articulate their ideas and positions. These observations are taken as evidence that substantive recipiency is not always symmetrically distributed in academic settings. Instead, the reactive practices of participants with lower authority status, which are typically the students, can remain limited to backchannels.

Oliveira et al (2007a) underscores the potential that research on reactive behavior has to illuminate specific interactional strategies that teachers can adopt in order to enhance their ability to respond to students in ways that are consistent with inquiry-based forms of science instruction. These research findings can be used to increase science teachers' awareness of effective recipient behaviors and enhance their abilities to manage teacher-student interaction, therefore leading to improved guiding and facilitating skills.

Farr (2003) examined the listening behavior or listenership displayed by language education tutors and their student teachers during dyadic debriefing meetings in the tutors' offices. A discourse analysis revealed that participants utilized three different types of linguistic signs: minimal response tokens or continuers (e.g., *yeah*, *mm hm*, *mm*, *yes*, *okay* and *no*), tokens by which listeners acknowledged the message being transmitted and encouraged the speaker holding the floor to continue; non-minimal response tokens or assessors (e.g., *right*, *exactly*, *sure*, *really*, *absolutely*, *fine*, *God*, *Jesus*, etc.), comments on the content being uttered that suggested a relatively higher level of emotional reaction on the part of the listener; and overlapping speech and interruptions (overlap with no speaker switch, overlap with speaker switch, and interruptions without overlap) which served as tokens of engaged listenership, thus having a positive effect on the dyadic conversations. Overall, minimal response tokens occurred over 8 times as frequently as non-minimal response tokens. Within the latter group, there was a predominance of confirmatory tokens (e.g., *right*, *exactly*, and *absolutely*), whereas more emotive and dramatic tokens (e.g., *excellent*, *wonderful* and *perfect*) were avoided. This finding was seen as related to the fact that tutor-student interaction took place in a somewhat formal setting wherein emotive responses tend to be considered inappropriate. Another important finding was that most interruptions and overlapping did not result in changes in the topic under discussion, which was interpreted as indication that participants used these devices to build an atmosphere of solidarity and cooperation, rather to dominate or control their interactions. Based on these observations, Farr (2003) argues that effective participation in academic discourse requires students and instructors to develop appropriate interactional skills for listening as well as speaking.

Farr (2003) conducts a systematic and extensive study of reactive tokens in instructional settings, focusing specifically on the emotive aspects of tutors and students' recipient choices. In doing so, this study makes an explicit connection between listening behavior and the previously discussed notion of engagement or involvement. Specifically, this study highlights that, while displaying listenership, participants select reactive tokens that convey levels of emotional engagement considered appropriate for the particular context in which their interactions unfold.

Nunn (1996) studied the discursive techniques utilized by effective university faculty members to encourage student verbal participation in whole-class discussions. Quantitative analyses of surveys and video-recordings of classroom interactions revealed statistically significant correlations between student participation (amount of time and number of students speaking in class) and frequency of faculty members' use of responsive behaviors such as praising students, probing for elaboration of students contributions (both answers and questions), accepting students' answers (e.g., "that's right"), and repeating students' answers. Other responsive behavior less frequently employed by faculty members included to use students' ideas and to correct students' wrong answers. The predominance of positive feedback (praises) over negative feedback (critical comments and corrections for students' wrong answers) was taken as empirical evidence that instructors can effectively foster a supportive classroom atmosphere by adopting positive responsive behavior in their interactions with students.

Nunn (1996) is the only study in this section that does not adopt a linguistic theoretical framework centered on the interactional notion of listening behavior. Instead, this study approaches the analysis of classroom interaction from an educational perspective, focusing on instructors' use of teaching techniques previously identified by educational research. Some of the techniques used by teachers to elicit student participation take the form of specific listening or responsive behaviors.

Discussion

The above studies draw attention to the fact that to be able to teach effectively, instructors have to develop interactional skills for listening as well as speaking. While listening to students, teachers need to react in linguistically, socially, and culturally appropriate ways in order to encourage student participation and foster a supportive classroom atmosphere. More than simply maintaining an open channel of communication or signaling attentiveness, teachers' recipient behavior needs to be aimed at checking, clarifying, exposing and substantiating students' meanings and positions. This can be accomplished through the employment of more than minimal listening strategies such as reformulating, extending and jargonizing (Waring, 2002); probing for elaboration of students contributions, and correcting students' answers (Nunn, 1996). Furthermore, teachers can avoid answering students' questions directly through strategic use of backchannels (Oliveira et al, 2007a) and encourage students to express their own ideas by offering confirmatory tokens (Farr, 2003), praising students, accepting students' answers and using students' ideas (Nunn, 1996).

Inquiry-based science teaching is commonly defined in terms of the adoption of student-centered questioning strategies that emphasize exploration rather than evaluation of students' emergent understandings. However, as the reviewed studies point out, developing appropriate responding skills just as important as developing appropriate questioning skills. By offering candidate understandings, teachers can extend students' ideas, introduce and reinforce scientific terminology, thus helping students express and articulate their own thoughts in manners that are consistent with scientific discourse (as opposed to simply telling students the right way of verbalizing their understandings). Adoption of such interactional strategies during inquiry science teaching seems vital for the establishment of more symmetric forms of social relationships between teachers and students.

Directives in Classroom Discourse

While regulative discourse has not been researched in the science education literature, several studies in the field of educational linguistics have explored the ways that teachers and students use directives in varied classroom settings. Dalton-Puffer and Nikula (2006) conduct a comparative pragmatic analysis of teachers and students' use of directives in classrooms of two different countries: Austria and Finland. The analysis focuses on verbal interactions recorded during the implementation of different types of classroom activities (whole-class discussions as well as hands-on activities), subjects (math, chemistry, biology, physics, geography, accounting, marketing, history, and business), and grade levels (4-13). In this study, directives are defined as speech acts wherein the speaker demands or requests the hearer to perform some kind of action (a command, order, warning, advice, or even a question). Furthermore a distinction is made between directives for physical acts and directives for information (requests for information such as questions). Because directives are inherently imposing or demanding, they may threaten the addressee's sense of self or "face" (Goffman, 1967). As a result, speakers' use of directives is largely influenced by a need for politeness in social encounters, an interactional constraint dealt with through the use of directive forms that have varied degrees of indirectness.

In both countries, requests for information related to curricular content tended to be made directly by both teachers and students; in other words, conventionally polite and modalized request forms (requests with modal verbs) typical of everyday situations were not used while performing directives for information. In contrast, requests for action tended to be performed almost exclusively by teachers, and typically involved the use of indirectness devices such as modal verbs (*would*, *could*, etc.), politeness marker (*please*), minimizers (*just*, *little*, *quite*, etc.), hedges (*kind of*, *sort of*), question instead of statement (*can you*…?), parentheticals (*I think*…), and shifts in deictic centre (*let's*, *you*, *we*). Furthermore, frequency of instructional directives was affected by contextual factors such as size of class and type of classroom activity. Teacher directives were twice as common in Austria (where classrooms had more students and a larger share of whole-class discussions) as they were in Finland (which had smaller classes and where students commonly worked on hands-on activities in small groups). Conversely, Finnish students uttered twice as many directives as did their Austrian counterparts. Another influencing factor was student age. Teacher-led activities and teachers' directives for information tended to be most frequent in lower grade levels, where students had limited language skills.

Based on the above findings, Dalton-Puffer and Nikula (2006) argue that the impositional value of directives (i.e., the degree of "imposingness" of directive statements) can be influenced by contextual features of individual classrooms. In settings where transmission of curricular information has a central status, directives for information are fully sanctioned, hence having a lower impositional weight than directives in individually-oriented social talk. In other words, requests for information are less face threatening, and both teachers and students have the right to perform them directly, without face-saving interpersonal work. Instruction in such educational settings tends to be mostly teacher-led, a type of classroom activity that affords students considerably less opportunities to use directives.

Dalton-Puffer and Nikula's (2006) study has a solid theoretical framework in which the type of speech act that the researchers set out to examine is defined in a concise and clear manner. In other words, the researchers convey clearly what is meant by the term "directive." Nonetheless, the study appears to be designed in a problematic way. There seems to be too much variation in terms of the classroom settings selected for data collection and, as a result, the researchers end up comparing college level courses to elementary classrooms, and classes as disparate as history, business and chemistry. Therefore, it becomes very difficult to discern whether differential use of directives reflects mainly differences in cultures, subjects or grade levels.

Tapper (1994) examined how a demonstrator (a native speaker of Chinese) used directives in an electrical engineering laboratory of an Australian University. A discursive analysis of the demonstrator's lab discourse revealed that he made use of several directive forms. His directives to students tended to fall into two major categories: *you* + *verb* forms (*you* + *verb*; *you* + *neg* + *verb*; *when*/*then* + *you* + *verb*; *I think* + *you* + *verb*; and *you* + *modal* + *verb*) and imperatives. These directive forms served several functions including speak about general procedures, point out how to accomplish specific tasks, describe how to use equipment, and suggest changes. Although the demonstrator sometimes used imperatives successfully, he tended to overuse *you* + *verb* forms, mostly in instances where a native English speaker would probably have used imperatives.

Tapper (1994) suggests that the demonstrator's excessive use of *you* + *verb* forms may have been associated with difficulties in expressing power and solidarity in that particular teaching context. Native English-speaking teachers usually avoid excessive statements of power (imperatives and *I*/*you* distancing patterns of pronoun use), instead they tend to rely on solidarity-promoting devices such as using the inclusive pronoun "we" as well as declaratives and interrogatives (which can be interpreted by students as directives only if the teacher has a well defined role). This does not seem to be the case of the demonstrator, who seems to have a poorly defined role in that particular teaching context. His institutional position is similar to that of a teaching assistant whose job is only to help students carrying out experiments rather than being the actual course instructor. A poorly defined role, combined with a limited English proficiency and non-native cultural background could have prevented the demonstrator from making more effective use of solidarity-building strategies. Instead, he could have opted to use "you" directive forms as an alternative way of avoiding the use of imperatives.

Overall, Tapper's (1994) study seems well designed and conducted. Its only limitation is that the author does not interview the instructor in order to establish whether there are any deliberate reasons or intentions behind his overuse the pronoun "you." Instead, the analysis seems somewhat speculative, entertaining an excessive number of possible explanations for the observed linguistic phenomenon. Nonetheless, the study raises an interesting point, which is a potential connection between the lack of clarity in the instructor's role and his inability to "hide" institutional power (or authority) through the use of solidarity-building devices.

Iedema (1996) examined the talk of early and late primary teachers during science and writing lessons, focusing specifically on the ways that teachers expressed or realized commands - speech acts aimed at organizing students in a learning activity. The study adopts Halliday's (1985) theoretical framework, which states that commands can be realized as imperatives (*Read the book*), declaratives (*You are required to read the* book) or interrogatives (*Can you read the book, please?*). Moreover, in realizing commands, speakers can either involve both the commander and the commanded in the speech act (subjective realization), or attempt to distance the commanding "I" from the commanded "you" through the use of impersonal forms (objective realization). The former includes imperatives (*Do your homework*), subjective declaratives (*You should do your homework; I want you to do your homework*) and subjective interrogatives (*Can you do your homework? Will you do your homework?*). In contrast, the latter type includes objective declaratives (*It is required that you do your homework*), and objective interrogatives (*Are you able to do your homework? Are you willing to do your homework?*). While subjective realizations rely mostly on modal verbs (*must, should, can*, etc.) as well as process verbs (e.g., *want*, *like*), objective realizations require the use of highly impersonalized, objectifying verb constructions that hide the source of the command, taking it out of the realm of interpersonal meaning and grounding it on objective reasoning (e.g., *be required to*, *be supposed to*, *be expected to, be able to*).

Iedema's (1996) analysis revealed that early primary teachers tended to make use mostly of subjective commands while late primary teachers used highly impersonalized and objectified commands. The occurrence of these two distinct forms of control in different grade levels is explained in terms of the establishment of classroom rituals or ceremonies. In early primary classrooms, students need to be positioned as being the subject of personalized control in order to be inducted into practical ceremonies or rituals. In other words, agreement on classroom behavior has to be established before activities can take place. In contrast, late primary teachers' reliance on objectified forms of control is based on the presumption that classroom behavior has become agreed upon and regularized. Progression toward objectified forms of control is only possible when there is common agreement on classroom practices and behavior.

Iedema's (1996) study has a solid theoretical base, a feature that serves to strengthen the analysis of subjectivity and objectivity in the use of directives by primary teachers. However, like Dalton-Puffer and Nikula (2006), this study examines classroom discourse across a wide range of school disciplines. Furthermore, little information is provided about the educational features of the classroom contexts in which data collection occurs. As a result, it remains unclear what topics are under discussion or what activities are being implemented (i.e., whether whole-class discussions, small-class discussions, or expository lectures)

He (2000) studied the use of directives by teachers in two different classroom settings in the U.S. where students (aged from 4.5 to 9) attended evening or weekend Chinese language classes. Directives were defined as verbal attempts made by the teacher to sway students to behave or act according to his/her wishes. Furthermore, a distinction was made among four different types of directives: instructional directives (issued in the process of implementing a classroom procedure or activity), disciplinary directives (used to discipline students' problematic behavior), initiating directives (used to initiate student talk or action), and responsive directives (issued in response to students' previous talk or behavior).

Teachers' directives followed recurrent patterns. Instructional/initiating directives tended to be constructed in three main ways: 1) discourse marker + imperative (e.g., *okay, let's begin our class*), 2) test question + imperative (e.g., *What should we do next? Write answers down),* and 3) modalized preference/permission statements (e.g., *You can read the book*). In the first construction type, the discourse marker "okay" was used to punctuate in an orderly manner the uttering of instructional directives, that is, it signaled to students that instructions concerning the classroom agenda were about to be uttered. Similarly, the test questions posed by teachers before issuing a directive also served an anticipatory function. These questions also created an interactive space for students to demonstrate their knowledgeability of the classroom agenda by giving them a chance to predict the directive that was about to be issued by the teacher. Finally, teachers adopted the use of modal verbs as a strategy to mitigate the imposing tone of their directives. As a result, teachers' directives were presented as being optional rather than mandatory even though the instances in which they were used presented no room for negotiation.

Rather than taking the form of simple prohibitive commands (e.g., *do not do X*), most disciplinary/responsive directives were preceded by an orientation phase in which students' behavior was made questionable through reference to a context of observable circumstances, as well as an evaluation phase in which the teacher formulated the consequences of students' behavior. Furthermore, in the evaluation phase, teachers invariably used "if-not" conditionals that highlighted the negative consequences of students' actions (e.g., *if you do not stop talking you will not learn*), as opposed to if-conditionals that would have pointed to the positive outcomes of behavioral change (e.g., *if you stop talking you will learn*).

Based on the above findings, He (2000) suggests that the interactional and grammatical structures of teachers' directives constitute a rich means for the socialization of cultural values to students. In using modalized/moralized directives to ask students to do something in the classroom, not only do teachers initiate classroom activity, but they also convey to students cultural information with respect to what constitutes expected, desirable, and acceptable behavior.

He (2000) uses a clear classification system for teacher directives, collects data across comparable classroom settings (with no excessive contextual variation), and establishes clear focal points (grammatical form, interactional function and frequency of directives). As a result, the analysis of teacher directives seems very well focused and clear. The only limitation seems to be the fact that it remains unclear what pedagogical implications the above findings can have for teachers.

Manke (1997) examined the use of politeness formulas and indirect discourse strategies by four elementary teachers (one student teacher and three in-service teachers with varied amounts of teaching experience) in first- and fifth-grade classrooms. Discourse analysis revealed that elementary teachers expressed their wishes to students in oblique or indirect ways more often than they used direct commands to tell students what to do. Specifically, teachers tended to use politeness formulas such as questions in place of commands (e.g., *would you like to sit down?* instead of *sit down*), mentions in place of commands (e.g., *it's noisy in this room* instead of *be quiet*), statements of preference in place of commands (e.g., *I prefer that your desks are clean* instead of *clean up your desks*), requests with politeness markers (e.g., *please*, *thank you* and *excuse me*) and modals (e.g., *would* and *could*) instead of commands. Other indirect discourse strategies included: using the pronoun *we* rather than *I/you* pairs, praising desired student behavior rather than criticizing undesired behavior, stating general behavioral principles rather than criticizing the behavior of particular students or issuing a prohibitive command, and using silence or touch to correct student behavior instead of giving a direct command.

In spite of the indirectness in teachers' commands, there was little or no evidence that students were confused. Instead, students tended to respond to teachers' seemingly polite requests or neutral statements as though they were in fact commands. There were also occasions wherein students resisted the teachers' indirect discourse strategies, forcing the teachers to issue more direct statements. Furthermore, teachers' use of indirect discourse strategies varied considerably depending on whether the interactions they were engaged in concerned student behavior or the learning activities that students were conducting. The two least experienced teachers tended to use direct commands to express behavioral expectations for students, and to make indirect statements about the students' learning activities. Conversely, the most experienced teacher tended to be more indirect in the area of student behavior, and more direct in the area of learning activity. Finally, the last teacher rarely used indirect strategies in either area.

In light of the above findings, Manke (1997) argues that there are several reasons behind the teachers' heavy reliance on indirect discourse strategies, including to protect the self-esteem of their students (their sense of personal dignity or face), to avoid subduing students' thinking, and to avoid confrontations and student rebellion. Furthermore, Manke (1997) also suggests that indirect discourse strategies may be a potential sign of better-quality teaching.

Although Manke's (1997) study contains a detailed ethnographic description of the classroom settings in which teacher-student interactions took place, no information is provided with regard to disciplines and topics being taught, or classroom activities being implemented. There seems to be an underlying assumption that the interactional phenomena being analyzed are ubiquitous to all classrooms. Furthermore, unlike other studies, Manke (1997) defines regulative discourse in terms of power relations rather than teacher directive behavior. Despite this apparent difference in theoretical framework, the reported findings seem to be consistent with those of other studies.

Discussion

The above studies illustrate the strong potential that research on teachers and students' performance of directives has to inform contextual features of particular classroom settings. The reported findings provide evidence that factors such as relative emphasis on knowledge transmission, class size, student age, and type of classroom activity can influence the impositional weight of directives, thus resulting in the use of varied degrees of directness (Dalton-Puffer & Nikula, 2006). Because inquiry-based instruction tends to be student-centered, it seems plausible to expect directives for information to have a higher impositional weight and thus be performed more indirectly than directives for action. Such pattern of directive use would be the exact opposite of more traditional content-centered classrooms.

There is also some indication that the use of solidarity building linguistic signs can be contingent upon the teacher having a well defined interactional role (Tapper, 1994). Since teachers' interactional roles in inquiry-based classrooms are less clearly defined than in traditional classrooms, teachers may have difficulty using solidarity-building devices as a strategy to "hide" their institutional power (or authority). Research also shows that the use of objectified directives is only possible when there is agreement among teachers and students on appropriate classroom ceremonies and rituals (Iedema, 1996). Considering that inquiry-based instruction does not have a definite sequence of instructional steps (less structure than traditional science instruction), it might be the case that teachers in higher grade levels may tend to use subjective directives.

The studies reviewed above also identify several strategies that teachers can adopt in order to improve their use of directives in inquiry-based classrooms. For instance, teachers can preface their directives with anticipatory verbal cues such as discourse markers and questions in order to increase the chances that students will receive their directives (He, 2000). Teachers can also strategically use politeness formulas and indirect requests instead of direct commands in order to protect students' face and maintain a collaborative classroom atmosphere (Dalton-Puffer & Nikula, 2006; He, 2000; Manke, 1997).

One important limitation of this literature is that it provides poor descriptions of the educational features present in the classroom settings in which teacher-student interactions take place. For instance, none of the above studies clarify whether science instruction occurs in an inquiry-based context or some other type of learning environment such as verification-oriented lab activities. The latter is more likely to be the case since inquiry-based learning remains relatively uncommon in most science classrooms.

Inquiry-Based Professional Development

The science education literature contains several reports of long- and short-term professional development programs facilitated by science educators while seeking to improve in-service teachers' ability to utilize inquiry-driven methods of science instruction in their classrooms. These programs offered K-12 science teachers varied types of development opportunities, often combining interventions such as immersion into scientific inquiry, expert instruction on curriculum design, delivery and assessment of inquiry learning, expert modeling of inquiry-based science lessons, provision of both peer and professional feedback, and participation in collaborations and action research. The impact of such programs was typically assessed through qualitative and quantitative analyses of classroom practice, teachers and students' views of scientific inquiry and inquiry-based teaching, as well as measures of student achievement in science.

Long-Term Expert Instruction and Support

Several longitudinal studies provide accounts of long-term training interventions in which science teachers take part in workshops that rely heavily on expert instruction, support, and feedback during planning and delivery of inquiry-oriented instruction. Akerson and Hanuscin (2007) conducted a three-year professional development program wherein elementary teachers attended monthly workshops that emphasized immersion in scientific inquiry and offered explicit-reflective instruction on pedagogical strategies for teaching nature of science (NOS) and inquiry. Instruction was based on vignettes and anecdotes from transcribed recordings of the teachers' own classroom practices. Furthermore, during the workshops, teachers adapted and revised their schools' science curriculum into an inquiry format that explicitly addressed aspects of NOS, and shared ideas and classroom practice through active participation in debriefing sessions in which they watched peer-taught lessons and provided mutual feedback. Another important component of the program was the continuous provision of on-site mentoring visits that allowed developers to model inquiry- and NOS-oriented science lessons in the teachers' classrooms, observe teachers' instructional practice, provide individualized support and feedback to teachers, and inform subsequent workshops. Overall, there were positive changes in the teachers and students' NOS views, and improvement in the teachers' ability to integrate scientific inquiry and NOS instruction into their classroom practices.

Unlike other professional development programs reviewed in this section, Akerson and Hanuscin (2007) combine participation in scientific inquiry with "explicit reflective" instruction aimed specifically at improving elementary teachers' understandings of NOS. This program is unique in the sense that its primary goal is to enhance teachers' ability to teach NOS content through inquiry, whereas other programs seek to prepare instructors to teach science content through inquiry.

A similar approach was taken by Wee, Shepardson, Fast, and Harbor (2007) who also conducted a three-year professional development program focused on enhancing K-12 teachers' ability to design and implement classroom investigations of environmental concepts and issues. The program facilitators used pre- and post- institute workshops, a four-week summer institute and classroom site visits to develop teachers' pedagogical and environmental knowledge as well as their inquiry skills and understandings. Throughout the program, teachers were provided with expert instruction and feedback on inquiry-based pedagogy, evaluated instructional resources and assessment tools, read and discussed inquiry standards, engaged in different approaches to inquiry teaching (i.e., field studies, environmental monitoring, investigative laboratories and models), were asked to develop and deliver an instructional plan that integrated the inquiry-based instructional approach modeled during the summer institute, and then shared and reflected on their teaching experiences. Although overall teachers' understandings of and ability to design inquiry-based instruction improved as a result of participating in the summer institute, teachers' classroom implementation tended to be inconsistent with the original inquiry design. Furthermore, classroom implementation of instructional plans had little impact on teachers' understandings of inquiry.

It is intriguing that the field component of the program facilitated by Wee et al (2007) does little to improve teachers' understandings of scientific inquiry and inquiry-based instruction. Unless teachers fail to reflect about their field experiences, it seems reasonable to expect teachers to develop more accurate and practical views of inquiry as a result of implementing inquiry science lessons in their classrooms.

Lee, Hart, Cuevas and Enders (2004) coordinated a three-year instructional intervention that sought to improve diverse students' science and literacy achievement by enhancing their elementary teachers' knowledge, beliefs and practices related to inquiry-based science instruction. Teachers from six elementary schools were provided with instructional units and materials developed by expert personnel and attended a series of four full-day workshops over the course of the academic year. In the first workshop, teachers received expert instruction on how to teach science through inquiry, adapted and implemented inquiry activities, and discussed their beliefs and practices. During the second workshop, expert personnel facilitated discussions on strategies for incorporating literacy activities into inquiry science lessons (e.g., reading trade books, writing expository paragraphs). After the discussion, teachers adapted and presented inquiry science lessons that incorporated literacy activities. The third workshop focused on the importance of considering the role of students' home culture and language in science instruction.

Expert personnel instructed teachers about how to incorporate students' home language, how to assist pupils with limited English proficiency, and to become aware of how particular cultural patterns of classroom communication and interaction can either encourage or inhibit students' participation in science classroom discussions. During the final workshop, teachers shared their teaching experiences, critiqued the instructional material, and commented on student performance. Although participating teachers reported improvements in their science content and pedagogical knowledge, increased confidence in their science teaching abilities, and stronger beliefs in the importance of providing inquiry-based instruction to diverse students, expert personnel did not observe significant changes in the teachers' actual classroom practices.

Lee et al (2004) is the only program to provide elementary teachers with expert instruction focused specifically on classroom patterns of communication and interaction. However, little information is provided about the specific instructional format adopted or interactional topics covered. Furthermore, instruction on classroom interaction seems limited, constituting just one of many topics covered in the third day of the program.

Basista, Tomlin, Pennington, and Pugh (2001) directed an inquiry-based integrated science and mathematics professional development program that consisted of administrator workshops, two summer institutes, academic-year seminars and classroom visitations. Administrator workshops served to enhance school principals' familiarity with inquiry-based instruction and national and state standards, whereas summer institutes provided K-12 teachers with expert modeling of inquiry and cooperative teaching methods, opportunities to collaboratively develop and facilitate inquiry activities that integrated science and mathematics, and a chance to receive feedback from peers. Furthermore, while implementing inquiry activities in their classrooms, teachers received expert support and feedback through classroom visitations, and shared their teaching experiences during follow-up seminars. Teachers who participated in the program showed gains in content knowledge and improved confidence and ability to implement inquiry-based curriculum that integrated science and mathematics.

An interesting feature of the program offered by Basista et al (2001) is that it emphasizes the need for teachers to be allowed to reflect about and process their professional development experiences. In order to create time for reflection, the program facilitators scheduled “time-off” periods between professional development activities. However, the provision of “time-off” was an ineffective strategy for fostering reflection as teachers tended to use these periods for other purposes.

Scientific Research Institutes

Some programs emphasized participation in full or open scientific inquiry, an approach in which in-service teachers were exposed to “real” research activity by collaborating with or being mentored by scientists. Jeanpierre, Oberhauser, and Freeman (2005) offered a professional development opportunity in which groups of secondary science teachers and a few of their students attended two one-week research institutes that emphasized participation in full inquiry on monarch butterfly ecology. The two institutes coincided with particular stages of the monarch butterfly annual cycle - breeding (during the summer in Minnesota) and migration (during the fall in Texas) – and were held in locations with natural areas to conduct short ecology research projects. In the first institute, scientists provided intensive instruction on ecology topics, science process skills and inquiry-based teaching and learning. Teachers and students worked alongside scientists on short authentic inquiry projects and planned an independent research project. During the time between the two institutes, participants conducted their independent inquiry projects and monitored monarch eggs and larvae in sites near their schools.

Staff scientists visited research sites and mentored participants while conducting these two open inquiry projects. During the second research institute, participants analyzed the collected data, presented their findings and prepared a written report. The number of teachers using full inquiry instructional activities in their classrooms increased significantly after they participated in the program.

Jeanpierre et al (2005) report the only professional development program to engage both teachers and students in scientific inquiry. Student participation is meant to encourage teachers to try out new teaching practices as they learn science through inquiry, to give teachers a chance to see that their students are able to carry out open inquiry, and to allow teachers to observe their students' reactions to the inquiry projects. However, it is reported that the presence of students also leads to problems such as a tendency among teachers to view the institute as a learning opportunity for their students and not for themselves.

A similar approach was taken by Lotter, Harwood and Bonner (2006) who conducted a two-week summer research institute that provided secondary science teachers with morning sessions of expert instruction and modeling of inquiry teaching, and afternoon firsthand experience with science inquiry in biology and chemistry research laboratories. While in the laboratories, teachers joined on-going investigations and participated in day-to-day research activity such as design and execution of experiments, data collection and analysis, etc. In the morning sessions, teachers also developed and presented inquiry-based science lessons, reflected on how to translate their laboratorial experiences into classroom activities, read articles about inquiry teaching and student learning, and wrote daily reflections. After participating in the institute, teachers expressed more confidence in their ability to utilize inquiry-based pedagogy. Furthermore, afternoon laboratory experiences led to an increase in teachers' science content and procedural knowledge, and encouraged teachers to recognize the value of repeating experiments, problem solving, and collaborative work. Nonetheless, teachers made only minor adjustments to their teaching practices (minor incorporation of inquiry-based strategies learned in the research institute).

An interesting aspect of the approach taken by Lotter et al (2006) is the emphasis they place on allowing science teachers to guide the direction and focus of the professional development program. This was accomplished by offering expert instruction and curriculum design sessions aimed at helping teachers solve specific student learning problems (“student learning bottlenecks”) that the teachers had identified in their own classrooms.

Caton, Brewer and Brown (2000) sought to promote the use of inquiry-based science teaching methods in middle and high schools by facilitating institutes in which certified science and mathematics teachers worked collaboratively with research scientists while engaged on open-ended investigations related to the topic of energy (e.g., using everyday supplies to build a windmill that would produce the maximum amount of electricity). For a period of two or three days teachers and scientists engaged in energy-focused inquiries; participated in group discussions in which they were asked to reflect about their cooperative experiences and how to adapt such investigations for implementation in their own classrooms; and developed inquiry-based lesson plans. Participation in the institute led to an increase in teachers’ confidence and use of inquiry-driven instructional methods. Furthermore, classroom assessments revealed higher levels of student satisfaction and less friction among classmates during science investigations after the institute. Lastly, participating scientists reported an increased familiarity with inquiry-based science teaching principles. These outcomes are taken as evidence that teacher-scientist collaborations can benefit both parties. Teachers can enhance their understandings of science concepts and processes, while researchers are provided with an opportunity to learn about educational practices and student needs.

Unlike other professional developers, Caton et al (2000) placed heavy emphasis on creating a professional development environment wherein teachers and scientists shared an equal expert status (educational and scientific expertise, respectively). During the program, personnel facilitated group interactions and used only low-tech, commonly available materials (e.g., cardboard, plastic, rubber bands, etc.) in order to ensure full and equal participation of teachers, and at the same time prevent domination by scientists. Such strategies successfully fostered teacher-scientists partnerships that often lasted beyond the institute.

Collaborative Programs

Other science educators implemented inquiry-based development programs that emphasized teacher participation in collaborative efforts. Instead of providing an extensive amount of expert instruction on how to foster inquiry in K-12 classrooms, these educators encouraged teachers to take on the role of educational experts-researchers and utilize their valuable contextual knowledge and classroom experience while collaborating with peers and professional developers. For instance, Buck, Latta, and Leslie-Pelecky (2007) included participatory action research as part of their development program for middle level science teachers. After a one-day immersion experience into inquiry on electricity and magnetism, teachers were engaged in cooperative discussion sessions in which they reflected about their immersion experience, articulated a collective understanding of inquiry learning, and planned a three-month field investigation on fostering an inquiry environment during the implementation of an instructional unit in their classrooms. A program facilitator visited teachers' classrooms and provided them with reflective feedback (commentary and questions) on a weekly basis.

Teachers then participated in focus-group discussion/reflections in which they shared the results of their investigations with peers and program facilitators. Although teachers held similar views of inquiry-based instruction, they tended to emphasize either mental aspects of scientific inquiry (i.e., allowing students to guide their own thinking process) or its physical aspects (i.e., allowing students to be physically active), leading to the occurrence of divergent classroom practices.

Buck et al (2007) deliberately avoided interventions that encouraged teachers to simply imitate or copy particular inquiry practices (e.g., expert modeling and instruction sessions), adopting instead a reflective model for professional development that encouraged teachers to change the social realities of their own classrooms through a joint inquiry process.

In contrast, Johnson, Kahle, and Fargo (2007) sought to increase student achievement in science by offering inquiry-based professional development at the school level, that is, instead of targeting individual science teachers from different schools, professional developers encouraged whole-school involvement in a collaborative and sustained development effort. First, a team of teachers and school administrators from a single middle school attended a two-week summer institute in which participants were immersed in inquiry and introduced to inquiry teaching standards, examined and reflected about inquiry-based instruction, adapted science curriculum, and designed a professional development plan to be implemented in their school. Then, for a period of three academic years, the team held monthly meetings in which all science teachers in the middle school collaboratively adapted existing curriculum, created and continuously revised new investigative lessons, aligned each grade's curriculum with state teaching standards, discussed authentic assessment and shared their experiences managing investigative science classrooms. Although the team received support from an education professor, who served as a coach, all collaborative sessions were led by team members. The program increased teachers' use of inquiry-based instructional practices and had a positive impact on students' performance in science.

Johnson et al (2007) offered the only whole-school professional development program reviewed in this section. As reported in the study, whole-school involvement was meant to ensure that students had continuous opportunities to experience inquiry-based experiences over the years, provide teachers with the opportunity to engage in long-term collaborations, and foster the formation of a community of learners in the school.

Discussion

The above studies highlight that a variety of approaches were taken by science educators who set out to offer inquiry-based professional development opportunities to practicing teachers. These efforts tended to rely mainly on the provision of long-term expert instruction and support (Akerson et al, 2007; Basista et al, 2001; Lee et al, 2004; Wee et al, 2007), participation in full scientific inquiry (Jeanpierre et al, 2005; Lotter et al, 2006) and participation in collaborative efforts (Buck et al, 2007; Johnson et al, 2007). A common thread running through all of these programs was that professional development invariably involved immersion into scientific inquiry. Typically, immersion experiences occurred early in the programs and was then followed by reflective discussions, expert instruction, and/or collaborative sessions. Furthermore, although all programs reported subsequent improvements in teachers' views, understandings, knowledge, design abilities, implementation abilities, and confidence with regard to inquiry-based science instruction, several studies reported failures to stimulate significant changes teachers' actual classroom practices (Lee et al, 2004; Lotter et al, 2006; Wee et al, 2007). These difficulties indicate that improvements in teachers' views, understandings and abilities related to inquiry-based instruction do not always lead to changes in classroom practice. Therefore, further consideration must be given to the type of barriers or difficulties that might be preventing teachers from translating their newly acquired knowledge, views, and abilities into actual inquiry-based classroom practice.

One important limitation of the professional development programs reviewed above is that they tend to overlook the teacher-student interactional dimension of inquiry-based science teaching, focusing instead on other instructional aspects such as designing appropriate inquiry science lessons, adopting effective teaching strategies, taking particular sequences of instructional steps, and evaluating student learning. Lee et al (2004) is the only study to report a program that draws teachers' attention to communicative and interactional aspects of inquiry-based science instruction. However, this program seems to pay only minor attention to interactional issues, a limitation that can partially explain the program's failure to engender significant changes in teaching practices. This failure suggests that it may take more than a relatively short session of expert instruction to get teachers to adopt less authoritative interactive and communicative patterns. Such an outcome is likely to require longer, clearly focused and systematic interventions aimed specifically at improving teachers' awareness of the teacher-student interactional dimension of inquiry-based science instruction.

Conclusion

Research on instructional and regulative discourse in a variety of classrooms settings has identified several interactional strategies that science teachers can adopt in order to reduce their traditionally high authoritative status while implementing inquiry-based science lessons in their classrooms. These interactional strategies provide teachers with specific ways of talking to students that can foster the establishment of more symmetric forms of social relationships. For instance, studies of instructional discourse in inquiry settings indicate that teachers can relinquish their authoritative role by following up on rather than evaluating students' ideas (Tabak & Baumgartner, 2004; Wells, 1993), allowing and encouraging students to ask questions (Polman, 2004), avoiding evaluative moves (Oliveira et al, 2007a), and adopting student-centered questioning practices that encourage pupils to construct well-developed and elaborated scientific understandings (Chin, 2007; Konfetta-Menicou & Scaife, 2000).

Analyses of teacher-student interaction mainly in the field of educational linguistics indicate that in order to become effective facilitators of inquiry-based science instruction teachers also need to be able to use solidarity-building personal pronouns to promote the emergence of a cooperative and consensual classroom atmosphere (Oliveira et al, 2007a; Rounds, 1987a; Wortham, 1996), strategically employ hedges to avoid giving explicit evaluations of students work (Oliveira et al, 2007a; Rowland, 2000), speak in ways that encourage students to become emotionally involved or engaged in their classroom activities (Csomay, 2006; Nunn, 1996; Oliveira et al, 2007a; Rowland, 2000; Simpsom & Mendis, 2003), and respond to students in ways that encourage them to articulate and elaborate their own thoughts and ideas (Farr, 2003; Nunn, 1996; Oliveira et al, 2007a; Waring, 2002).

Similarly, studies of regulative discourse have revealed several strategies that teachers can adopt in order to improve their ability to direct students in inquiry-based classrooms, including prefacing directive statements with anticipatory verbal cues to increase the chances that students will receive their commands (He, 2000), using politeness formulas and indirect requests instead of direct commands in order to protect students' face (Dalton-Puffer & Nikula, 2006; He, 2000; Manke, 1997), employing solidarity-building devices to establish a collaborative classroom atmosphere (Tapper, 1994), and issuing objectified and impersonal directive statements to control students in less authoritative ways (Iedema, 1996).

Awareness of and ability to utilize the above set of interactional strategies can provide science teachers with a large repertoire of discursive skills for managing teacher-student verbal exchanges in ways that are conducive to the establishment of symmetric interactional patterns as inquiry-based science learning and teaching demand. However, inquiry-based professional development opportunities recently offered to practicing teachers have failed to recognize the importance of improving in-service teachers' communicative and interactional skills. Instead, professional developers have sought mainly to improve science teachers' views and understandings of inquiry as well as their abilities to design and implement inquiry science lessons through the provision of long-term expert instruction and classroom support (Akerson et al, 2007; Basista et al, 2001; Lee et al, 2004; Wee et al, 2007), scientific research institutes (Jeanpierre et al, 2005; Lotter et al, 2006), and collaborative programs (Buck et al, 2007; Johnson et al, 2007). These professional development programs have for the most part disregarded the findings of research on teacher-student discourse, thus failing to foster teachers' awareness of the teacher-student interactional dimension of inquiry and to develop teachers' abilities to employ the large number of interactional strategies identified in this literature. Without having access to professional development opportunities aimed specifically at enhancing their interpersonal skills, it remains unlikely that in-service teachers will be able to effectively cope with the complex interactional demands of inquiry-based teaching.

Chapter 3

METHODOLOGY

Introduction

The literature reviewed in Chapter 2 highlights how current inquiry-based professional development efforts have the most part disregarded the findings of a growing number of research studies suggesting that effective inquiry-oriented science instruction can be contingent upon teachers developing appropriate management skills for coping with the complex demands of symmetric forms teacher-student interaction (Chin, 2007; Chin, 2006; Mortimer & Scott, 2003; Oliveira et al, 2007a; Polman, 2004; Roth, 1996; Tabak & Baumgartner, 2004; van Zee, Iwasyk, Kurose, Simpson & Wild, 2001; van Zee & Minstrell, 1997a; van Zee & Minstrell 1997b; Wells, 1993; Yip, 2004). Professional developers responsible for such development efforts are yet to recognize the importance of making science teachers more mindful of the particular ways that they interact and communicate with students while integrating inquiry-based pedagogical methods into their classroom practices. The present dissertation study attends to this apparent gap in the professional development literature by designing, conducting and evaluating the impact of inquiry-based program focused primarily on enhancing elementary teachers' interactional views and abilities to interact with students.

The proposed study adopts a qualitative research approach (Bogdan & Biklen, 2003; Creswell, 2003) and has an ethnographic design, being aligned with social constructivist perspectives that emphasize that meanings are created in human social interaction (Robson, 2002). As part of this study, descriptive data are systematically collected through open-ended research methods such as classroom observations, surveys and semi-structured interviews, and then analyzed inductively to build a naturalistic account (Lincoln & Guba, 1985) of teachers' interpersonal views and abilities to interact with students in inquiry-oriented science classroom settings. Data collection and analysis are focused on the effects of an intervention (an inquiry-based professional development program), being guided by the following research questions and sub-questions:

3. How did the institute on teacher-student interaction influence elementary teachers' views of classroom inquiry?
    a. How did teachers view inquiry-base science instruction *prior to* the institute?
    b. How did teachers articulate their views *during* the institute?
    c. How did teachers view inquiry-based science instruction *after* the institute?
4. How did the institute on teacher-student interaction influence inquiry-based science teaching in elementary schools?
    a. How did teachers interact with their students while implementing classroom inquiries *prior to* the institute?
    b. How did teachers interact with their students while implementing classroom inquiries *subsequent to* the institute?

Table 3.1 provides a timeline for data collection and analysis, outlining dates in which specific phases of this study were conducted (see below).

Table 3.1

Data Collection and Analysis Timeline

Date	Phase
04/07 – 05/07	First classroom observations of inquiry-based science lessons
06/04/07 (morning)	First interviews with elementary teachers
06-15/04/07	Facilitation of inquiry-based professional development program
06/15/07 (afternoon)	Second interviews with elementary teachers
10/07 – 12/07	Second classroom observations of inquiry-based science lessons
01/08 – 02/08	Data transcription and analysis
03/08 – 04/08	Write-up (results, discussions, conclusions and implications)

Participants

Participants for this study were recruited from a group of fifteen in-service elementary teachers who attended the last summer institute of a three-year professional development program called "Scientific Modeling for Inquiring Teachers Network (SMIT'N)." These teachers came from eight different public schools from one district in Indiana where they had taught all subjects, including science, at grade levels K thru 6. Although the entire group of SMIT'N teachers was invited to participate in this study, only a small sample of three teachers was observed while implementing inquiry science lessons in their classrooms. Selection of this sample depended primarily upon teachers' willingness to take part in the "classroom observation" portion of this study.

Intervention

In its first two years, the SMIT'N program sought to enhance elementary teachers' understandings and abilities to incorporate scientific modeling, scientific inquiry and nature of science into their classroom practices through a combination of summer institutes, school year workshops, and classroom support. The third and last summer institute of the program was held in the summer of 2007, aimed primarily at enhancing elementary teachers' ability to interact with students while teaching science through inquiry. A more detailed description of this intervention is provided below.

Practicing elementary teachers were offered the opportunity to participate in a two-week summer institute with a schedule consisting of daily professional development activities divided into two three-hour blocks (one block in the morning and another one in the afternoon). The two blocks were separated by a one-hour lunch break, with morning blocks being held from 9 am to 12 pm and afternoon blocks from 1 to 4 pm. Furthermore, the institute met five times a week

(Monday thru Friday) over a period of two weeks, thus affording a total of 60 direct contact hours (see Table 3.2 below).

Based on the literature review presented in Chapter 2, a list of performance objectives to focus on in the summer institute was created. The list comprised a number of interpersonal skills that elementary teachers were expected to develop as a result of participating in the institute. The list of objectives emphasized that teachers were to develop the ability to:

1. introduce an inquiry science lesson in an effective manner, being able to
    a. create student involvement or engagement through the use of solidarity-building devices and conversational strategies such as parallel repetitions,
    b. and clearly identify the instructional goals and objectives of inquiry activities through effective use of directives;
2. effectively direct students while implementing inquiry lessons, being able to
    a. preface directives with anticipatory verbal cues,
    b. skillfully use politeness formulas and indirect requests to protect students' face,
    c. employ solidarity-building devices to create a collaborative classroom atmosphere,
    d. issue objectified and impersonal directives to control students in less authoritative ways,
    e. and use directives to clarify, redefine and reiterate instructional goals (to deal with student misbehavior);
3. use questions efficiently while facilitating inquiry science lessons to
    a. encourage student participation (maintaining student engagement or involvement),

b. elicit students' emergent understandings in non-authoritative ways,
c. assess students' emergent understandings,
d. and support students' explorations without leading them;

4. respond effectively to students' questions, being able to
    a. deal with students' requests for "the right answer" though strategic use of hedges,
    b. accept students' answers and ideas without evaluating them,
    c. and follow up on rather than evaluate students' ideas and thoughts;
5. employ a variety of listening strategies, including backchannels and more than minimal response tokens, to
    a. encourage students to express and articulate their own ideas,
    b. check, clarify, substantiate, expose, and elaborate students' emergent understandings,
    c. and introduce and reinforce scientific terminology.

The above objectives establish in a clear and concise manner a small number of specific interpersonal abilities as the institute's intended outcomes. As such, these objectives serve as a framework for the institute's "substance" (Lee et al, 2004), that is, they demarcate content-specific teaching behaviors and pedagogical strategies that teachers are expected to develop as result of participating in the professional development program.

Decisions with regard to the format or structure of the institute (i.e., types of professional development activities included in the program) were grounded on a review of the literature on inquiry-based professional development (see last section of Chapter 2). This literature indicates that, to be successful, inquiry-based programs have to offer expert instruction (Akerson & Hanuscin, 2007; Wee et al, 2007; Lee et al, 2004; Basista et al, 2001), immerse teachers in authentic science inquiry activities (Jeanpierre et al, 2005; Lotter et al, 2007), and encourage teachers to collaboratively examine their own teaching practices (Buck et al, 2007; Johson et al, 2007). In light of these previous development efforts, a professional development program was designed with a format that relied largely on the integration of three main components: *morning expert instruction sessions, midday inquiry immersion sessions*, and *afternoon collaborative assessment sessions*.

As shown on the schedule below (Table 3.2), with the exception of days 1 and 10, the summer institute's development activities followed the same daily routine. First, teachers participated in *morning expert instruction sessions* that lasted for approximately one hour and a half. Each day, teachers were instructed about a particular aspect of teacher-student interaction, including discursive structures, questioning (question types and student-centered strategies), responding (hedges and backchannels), solidarity-building (pronouns), directing (directives), and involving (parallel repetitions, rhetorical questions, etc.). After receiving expert instruction, teachers then took part in *midday inquiry immersion sessions* wherein program personnel modeled inquiry-based science lessons. These modeling sessions were divided into two parts of one hour a half each, one before and another after the lunch break.

At the end of each day, teachers participated in *afternoon collaborative assessment sessions* that lasted for approximately one hour and a half. In the first thirty minutes of these sessions, teachers were asked to discuss and critique the program personnel's interactional performance while modeling inquiry science lessons, focusing on the same interactional dimension on which they were instructed in the morning. After that, there were daily work hours in which teachers were asked to assess (individually or in groups) their own interactional performance by watching and critiquing video-recordings of their inquiry-based teaching practices. Each day teachers wrote a reflective report describing the findings of their discursive self-examinations. In the last day of the summer institute (morning of day 10), teachers shared their findings with peers by giving PowerPoint presentations.

Table 3.2

SMIT'N Summer Institute Schedule

Day 1	Day 2	Day 3	Day 4	Day 5
Semi-structured interviews	Expert instruction: discourse structure (IRE and others)	Expert instruction: types of questions	Expert instruction: student-centered questioning	Expert instruction: responding (hedging)
	Inquiry immersion	Inquiry immersion	Inquiry immersion	Inquiry immersion
Inquiry immersion	Inquiry immersion	Inquiry immersion	Inquiry immersion	Inquiry immersion
Inquiry immersion	Collaborative assessment	Collaborative assessment	Collaborative assessment	Collaborative assessment
Day 6	**Day 7**	**Day 8**	**Day 9**	**Day 10**
Expert instruction: responding (backchannels)	Expert instruction: pronouns and solidarity	Expert instruction: directing	Expert instruction: involving/ engaging	PowerPoint presentations
Inquiry immersion	Inquiry immersion	Inquiry immersion	Inquiry immersion	
Inquiry immersion	Inquiry immersion	Inquiry immersion	Inquiry immersion	Semi-structured interviews
Collaborative assessment	Collaborative assessment	Collaborative assessment	Collaborative assessment	

The summer institute's format is well aligned with National Science Education Teaching Standards (NRC, 1996) which recommend that professional development programs provide science teachers with opportunities to "learn essential science content through the perspectives and methods of inquiry" (Professional Development Standard A - Science Learning), "struggle with real situations and expand their knowledge and skills in the appropriate contexts" (Professional Development Standard B – Pedagogical Content Knowledge), and "have access to existing research and experiential knowledge" (Professional Development Standard C – Lifelong Learning). The summer institute's three main components (*inquiry immersion*, *collaborative assessment*, and *expert instruction*) offer development activities that meet all of the above standards.

The process of incorporation of technology-based learning strategies into the SMIT'N summer institute followed the framework for planning teacher professional development proposed by Loucks-Horsley, Love, Stiles, Mundry, and Hewson (2003). Guided by a clear set of goals and purposes, technology-mediated learning strategies that connected directly to teachers' practice, nurtured a learning community, and provided participants with numerous opportunities for reflection were pervasively integrated into the structure of the summer institute. The resulting program offers guided video-viewing experiences, whole-group discussions and presentations, and small group learning activities that are contextualized in the social reality of teachers' own classrooms.

The decision to include analyses of video-recordings of the participating teachers' own classroom practice as part of the SMIT'N summer institute was influenced by previous work in fields other than science education. Douglas and Myers (1989) employed videotaped segments of actual classroom performance to enhance international teaching assistants' (ITAs) communicative efficiency. Their approach was to videotape the classroom performance of several effective teaching assistants in courses such as physics, chemistry, and engineering, and then use short segments of tape to illustrate effective pedagogical, organizational, explanatory and interactive strategies during an ITA seminar. Boyd (1989) also developed a program to help ITAs develop teaching skills through the use of video technology. During this program, ITAs were videotaped while giving short presentations and then asked to conduct self-evaluations in order to become more sophisticated critics of their own teaching and develop professional self-images. Frankel and Beckman (1982) used a video-based method for enhancing interpersonal communication in the health care process by videotaping medical encounters between first-year residents and their patients. The videotapes were then reviewed by both the patient and provider, leading to more friendly and sociable interactions and to a decrease in the amount of interruptions. These research studies underscore the potential of video as a medium for focusing on specific aspects of a communicative event, particularly after the audience has been prepared to look for those aspects.

The summer institute design was influenced by sociolinguistic models of ITA program development that have advocated the use of "communicative competence" (Canale & Swain, 1980; Canale, 1983) as a theoretical basis for setting goals, designing curriculum and evaluating the outcomes of ITA instruction. These programs emphasize that the oral skills and communicative behaviors that are important for ITAs' teaching roles cannot be improved apart from the classroom context in which these skills and behaviors will be utilized (Hoekje & Williams, 1992). In a similar vein, the SMIT'N summer institute was designed to enhance elementary teachers' communicative competence by increasing their awareness of the unique set of social roles, relationships and patterns of language use found in their own classroom contexts.

Data Collection

This section contains a description of the methodological strategies that were adopted to collect data for the proposed research questions. The overall approach was to systematically gather information on elementary teachers' interactional views and abilities. These data were collected before, during, and after their participation in an inquiry-based professional development program aimed at enhancing elementary teachers' ability to interact with their students (see Table 3.3 for an overview of the methods data collection that were utilized for each research question). The means by which data for each particular research question was obtained is described below.

As pointed out at the beginning of the chapter, research question 1 (*how did the institute on teacher-student interaction influence elementary teachers' views of classroom inquiry?*) was divided into three smaller and closely related research questions. The methods of data collection utilized for each of these three research questions are described below.

Question 1.a: How did teachers view inquiry-base science instruction prior to the institute? In the first morning of the SMIT'N summer workshop, elementary teachers filled out the Initial Interactional Views Survey (see Appendix A) in which they were asked to describe and illustrate how they usually interacted with their students (i.e., their interactional roles and relationships) when they taught science through inquiry, and how these interactions differed from more traditional, content-centered approaches to science teaching. Teachers were also asked to identify their interactional strengths and weaknesses, report their previous interpersonal difficulties, and name those interactive skills that they considered to be essential for inquiry-based science instruction.

Table 3.3

Overview of the Methods of Data Collection, Data Analysis and Research Questions

Research Question	Data Collection Methods	Data Analysis Methods
(1.a) How did teachers view inquiry-base science instruction *prior to* the institute?	- Initial interactional views survey - Audio-recordings of teachers' semi-structured interviews at the beginning of the summer institute	Grounded theory: - transcription of audio-recordings - close reading, open coding, memoing, and focused coding with MAXqda2 program
(1.b) How did teachers articulate their views *during* the institute?	- Video-recordings of the summer institute sessions - Teachers' reflective reports - Teachers' PowerPoint files	Grounded theory: - transcription of video-recordings - close reading, open coding, memoing, and focused coding with MAXqda2 program
(1.c) How did teachers view inquiry-based science instruction *after* the institute?	- Final interactional views survey - Audio-recordings of teachers' semi-structured interviews at the end of the summer institute	Grounded theory: - transcription of audio-recordings - close reading, open coding, memoing, and focused coding with MAXqda2 program
(2.a) How did teachers interact with their students while implementing classroom inquiries *prior to* the institute?	- Video-recordings of inquiry science lessons before the institute	Microethnography: - transcription of video-recordings - selection and analysis of key cultural scenes
(2.b) How did teachers interact with their students while implementing classroom inquiries *subsequent to* the institute?	- Video-recordings of inquiry science lessons after the institute	Microethnography: - transcription of video-recordings - selection and analysis of key cultural scenes

After filling out the survey, thirty percent of the teachers were selected for semi-structured interviews. Multiple interviews with individual teachers were conducted simultaneously by the researcher and other SMIT'N personnel before the programs' development activities commenced (see Table 3.2). Using the Initial Interactional Views Survey as a script or guide, interviewers asked elementary teachers to elaborate on their views of the interactional aspects of inquiry-based teaching. All semi-structured interviews were audio-recorded. As Bernard (2002) points out, semi-structured interviews are based on the use of a general script or interview guide containing a list of topics that need to be covered and questions to be asked. This type of interview is open-ended, that is, although there is a list of predetermined questions, the interviewer has the freedom to modify the sequence and wording of questions, omit or add questions depending on their appropriateness to particular interviewees, and determine the amount of time and attention given to different questions or topics (Robson, 2002).

Question 1.b: How did teachers articulate their views during the institute? In order to track the development of teachers' interactional views throughout the summer institute (henceforth referred to as *teachers' emergent interactional views*), elementary teachers were video-recorded while receiving expert instruction and discussing current educational linguistic research (morning expert instruction sessions), while discussing their observations and critiquing program personnel's interactional performance (first 30 minutes of afternoon collaborative assessment sessions), and while sharing the results of their video-based discourse analyses with peers (PowerPoint presentations). Furthermore, teachers' daily reflective reports as well as the PowerPoint files they made for their final presentations were collected. In other words, characterization of teachers' emergent interactional views was based on oral data (teachers' contributions to expert-guided discussions) as well as written data (teachers' collaboratively produced artifacts).

Question 1.c: How did teachers view inquiry-based science instruction after the institute? At the end of the institute, teachers filled out the Final Interactional Views Survey (see Appendix B) wherein they were asked whether and how their views of teacher-student interaction in inquiry-based classroom contexts changed as a result of participating in the summer institute. In the survey, teachers were also asked to assess the importance and applicability of the communicative skills focused on in the institute (e.g., responding, questioning) to their own classroom contexts. Like in the first day of the institute, after filling out the survey, teachers were invited to participate in a second round of semi-structured interviews (Bernard, 2002; Robson, 2002) in which they were asked to elaborate on their responses to the Final Interactional Views Survey (used as guide or script by the interviewers). Once again, multiple individual semi-structured interviews were simultaneously conducted and audio-recorded by the researcher and other program personnel with approximately thirty percent of the participating teachers.

As pointed out at the beginning of the chapter, research question 2 (*how did the institute on teacher-student interaction influence inquiry-based science teaching in elementary schools?*) was divided into two smaller and closely related research questions. The methods of data collection utilized for each of these two research questions are described below.

Question 2.a: How did teachers interact with their students while implementing classroom inquiries prior to the institute? To answer this particular research question, a group of three SMIT'N elementary teachers were video-recorded while implementing inquiry-based science lessons in their classrooms prior to attending the summer institute. These video-recordings were captured with a digital camcorder focused mainly on the teacher who was asked to wear a wireless lapel microphone while talking to her students. Teacher-student interactions were initially stored on Mini DV videotapes and later burned onto Compact Discs (CDs) in a QuickTime™ format that allowed the video-recordings to be played on personal computers using a hypermedia software package.

The use of video technology, rather than audio, can vastly improve the precision of data collection by allowing both verbal and non-verbal aspects of teacher-student interaction to be captured on tape. Despite this advantage, video-cameras are more intrusive and tend to encourage participants to become more self-conscious and shape their behavior in order to project a particular image (Briggs, 1986). To deal with this issue and make teachers and students more comfortable, the researcher sometimes left the camera on a tripod positioned in the back of the classroom and participated in the science inquiry lessons. Participant observation is an effective way of lowering participants' reactivity to the use of video for continuous monitoring (Bernard, 2002).

Question 2.b: How did teachers interact with their students while implementing classroom inquiries subsequent to the institute? In the following school year, after having participated in the summer institute, the same group of three elementary teachers was video-recorded while implementing a second inquiry-based science lesson in their classrooms. These video-recordings were captured with a digital camcorder focused mainly on the teacher with a wireless microphone attached to her/his lapel. Again, teacher-student interactions were initially stored on Mini DV videotapes and later burned onto compact discs (CDs) in a QuickTime™ format so that could be watched on personal computers using a hypermedia software package. Participant observation continued to be used as a strategy to lower participants' reactivity to the video-camera (Bernard, 2002).

Data Analysis

A description of the process of data analysis is provided in this section. Overall, two different analytical treatments were conducted: 1) a *microethnographic analysis* of video-recordings in order to describe and illustrate patterns of teacher-student interaction during inquiry science lessons; and 2) a *grounded theory analysis* of teachers' reflective reports and PowerPoint files, audio-recorded interviews, and video-taped institute sessions in order to track the evolution of teachers' interactional views during the summer institute (Table 3.3 provides an overview of the methods data analysis that were utilized for each research question). These analytical methods are described in more details below.

Microethnographic Analysis

As pointed out in the previous section, teacher-student interactions were videotaped during the classroom implementation of inquiry science lessons both prior and subsequent to the summer institute. The resulting corpus of video-recordings was used as a source of data for the two research questions related to teachers' interactional abilities, namely question 2.a (*How did teachers interact with their students while implementing classroom inquiries prior to the institute?*) and question 2.b (*How did teachers interact with their students while implementing classroom inquiries subsequent to the institute?*).

A microethnographic analysis of the digital video-recordings was conducted in order in to describe and illustrate patterns of teacher-student interaction during inquiry science lessons. According to Erickson (1996), the term microethnographic analysis refers to the study of video-recorded social interaction in minute detail through an up-close and exhaustive examination of how people use language and other forms of communication to realize the social work of their daily lives. Bogdan and Biklen (2003) consider microethnographies to be case studies of very specific organizational activity (e.g., teacher questioning) with very small organizational units (e.g., inquiry science lessons).

This microethnographic approach to data analysis combined systematic examination of transcribed recordings with detailed sequential analysis and playback of video-recorded interaction. Discursive records of classroom interactions were carefully examined in order to identify the main interpersonal strategies employed by each teacher while interacting with their students at different moments of the inquiry science lessons. This examination was multi-focal, centering specifically on the seven aspects of teacher-student interaction identified in the literature reviewed in Chapter 2:

1. *Prevalent discourse structures.* As part of this focal point, teachers and students' interactional moves were examined in order to determine whether they followed particular discursive patterns such as IRE sequences (Lemke, 1990), IRF sequences (Chin, 2006; Wells, 1993), R-R couplets (Tabak & Baumgartner, 2004), student-initiated dialogues (Polman, 2004), IR sequences (Oliveira et al, 2007a) and IRFRF sequences (Mortimer & Scott, 2003).
2. *Teachers' questioning strategies.* This focal point included an analysis of teachers' abilities to employ uptake and display questions (Oliveira et al, 2007a); reflective discourse (van Zee & Minstrell, 1997a; 1997b); questions to draw out students' knowledge (Roth, 1996); questions to induce conceptual change (Yip, 2004); Socratic questioning, verbal jigsaw, semantic tapestry and framing (Chin, 2007); and questions to elicit student thinking (van Zee et al, 2001).
3. *Teachers' use of hedging*. This interactional aspect of classroom discourse focused on teachers' abilities to employ hedges such as plausibility and attribution shields, rounders,

adaptors as well as maxim hedges (Rowland, 2002); quotations of anonymous speakers, and the royal *we* (Fortanet, 2004); and, adverbs, juxtaposed ideas, tag questions, rising intonations and turn repairs (Oliveira et al, 2007a).

4. *Teachers' recipient practices*. This focal point referred to the reactive tokens commonly used by teachers to signal active listenership and to maintain an open communication channel with their students, including backchannels and candidate understandings (Oliveira et al, 2007a; Waring, 2002) as well as brief opinions, overlaps and interruptions (Farr, 2003).
5. *Teachers' use of directives*. This focal point included an examination of the grammatical forms and social functions of teachers' directives (Halliday, 1985; He, 2000) and an assessment of teachers' abilities to use: subjective and objective commands (Iedema, 1996), directives for information and action (Dalton-Puffer & Nikula, 2006), politeness and indirectness devices (Bills, 2000; Dalton-Puffer & Nikula, 2006; Manke, 1997; McH & Brazil, 1982; Rowland, 2002; White, 1989), and linguistic forms aimed at eliciting non-verbal responses from students (Holmes, 1983).
6. *Teachers' use of personal pronouns*. This focal point was concerned with teachers' use of personal pronouns as a means of organizing their interactions with students. More specifically, this examination focused on teachers' abilities to build solidarity with students (Oliveira et al, 2007a; Rounds, 1987a; Rounds, 1987b) and manage teacher-student interaction through the use of first, second and third person pronouns (Fortanet, 2004; Rowland, 1999; Tabak & Baumgartner, 2004; Wortham, 1992).
7. *Teachers' use of involvement-oriented strategies.* This examination focused specifically on teachers' ability to create student engagement and participation through the use of

linguistic devices such as parallel repetitions (Oliveira et al, 2007a); involved production, lack of abstract style, situation-dependent discourse and online elaboration (Csomay, 2006); idioms (Simpson & Mendis, 2003); and rhetorical questions, humorous comments, praises, and using students' names (Nunn, 1996).

Based on the above examinations, a microethnographic account of teacher-student interactions was written, describing and illustrating elementary teachers' performance along each of the seven interactional aspects described above. The scope of the resulting microethnography was limited to key cultural scenes of naturally occurring communicative interactions in the immediate classroom context of teacher-student discussions. These key cultural scenes revealed the intricacies of teachers' discursive practices prior and subsequent to the summer institute, thus allowing a careful assessment of the impact of the summer institute on teachers' interpersonal abilities.

Peer debriefing sessions were frequently held in order to triangulate emerging interpretations of the data. In these sessions, discursive records of particular cultural scenes were examined collectively, individual analyses shared, and interpretations discussed extensively. The emergent account was gradually adjusted to include any variation that surfaced from this reflective group interpretation of the data. These debriefing sessions were very important during the interpretative analysis of cultural scenes as they contributed significantly to guarding against individual researcher biases (Robson, 2002).

Grounded Theory Analysis

As indicated above, reflective reports, PowerPoint files, audio-recorded interviews, and video-taped institute sessions provided data for the three research questions related to teachers' interactional views. More specifically, question 1.a (*How did teachers view inquiry-base science* *instruction prior to the institute?*), question 1.b (*How did teachers articulate their views during the institute?*), and question 1.c (*How did teachers view inquiry-based science instruction after the institute?*).

The teachers' interactional views were obtained through the adoption of a "grounded theory" approach to qualitative data analysis (Glaser & Strauss, 1967). This approach calls for the iterative and combined use of interpretative and flexible methods of analysis such as close reading, inductive or open coding and memoing (Emerson, Fretz & Shaw, 1995; Bernard, 2002). There are no *a priori* hypotheses or codes. Instead, analytical categories emerge and are gradually refined based on close examination of meanings and patterns in the collected data.

The audio- and video-recordings were transcribed and then, along with the teacher-generated products, imported into a computer program called MAX qualitative data analysis (MAXqd2). After being imported, the data were separated into three different files called *views before the institute* (transcribed audio-recordings of the first teacher interviews), *views during the institute* (transcriptions of video-recorded institute sessions, reflective reports and PowerPoint texts) and *views after the institute* (transcribed audio-recordings of the second teacher interviews). Each of these files was then analyzed separately according to the procedure described below.

First, the texts were systematically read in order to generate coding categories for the teachers' interactional views. As pointed out by Emerson, Fretz and Shaw (1995), it is useful to have a set of guiding questions in the initial phase of open coding. The researcher can generate codes or categories by mentally turning the answers to these questions into words or terms that capture the information read on a piece of data. The following set of questions guided this close reading of the texts:

1. How are teachers describing teacher-student interactions?
2. What labels or metaphors are teachers using?
3. What interactional skills or aspects are teachers recognizing?
4. What assumptions are teachers making?

These questions focus specifically on the teachers' views of teacher-student interaction in the context of inquiry-based instruction and are designed to generate a particular type of code called "subjects' ways of thinking about people and objects" (Bogdan & Biklen, 2003). These are codes aimed at capturing participants' *understandings* of certain people or objects in their world rather than *processes* or *causes*.

The emergent coding categories were revised until patterns or themes in the teachers' interactional views become discernable. At this point, the texts were broken down into pieces and sorted into sets according to their relevance to each theme or pattern. The teachers' interactional views were then elaborated upon through a combination of focused coding (a minute, line-by-line analysis of each set) and memoing (detailed running notes about the coding themes). Upon completion of focused coding, a written report was produced summarizing and comparing themes in teachers' interactional views before, during and after the summer institute. Data display in this report was enhanced through the inclusion of excerpts from the coded textual materials (Dewalt & Dewalt, 2002). These excerpts served as illustrations of the themes or patterns that emerged from coding the texts.

Chapter 4

RESULTS: TEACHERS' VIEWS OF CLASSROOM INQUIRY

Introduction

Included in this chapter are the results of a grounded theory analysis that was conducted in order to characterize and track the development of elementary teachers' views of interactional aspects of classroom inquiry (or their interactional views of inquiry) throughout the two weeks of SMIT'N summer institute. The results are presented in chronological order, divided into three separate sections. The first section is focused on *teachers' initial interactional views*, that is, how teachers described inquiry-based classroom interaction prior to engaging in the professional development activities of the summer institute. In the second section, the focus shifts to *teachers' emergent interactional views*, that is, how teachers articulated interactional aspects of inquiry-based science instruction while participating in the institute's professional development activities. And then, the last section provides an account of *teachers' final interactional views*, that is, how teachers depicted the interactional dimension of classroom inquiry after having participated in the SMIT'N professional development activities. Combined, these three sections provide an answer to the first research question outlined in Chapter 1 (i.e., *how did the institute on teacher-student interaction influence elementary teachers' views of classroom inquiry?*).

Teachers' Initial Interactional Views

On the first day of the SMIT'N summer institute, prior to participating in the professional development activities, fifteen elementary school teachers were asked about their views of teacher-student interaction in the context of inquiry-based science instruction. A description of the teachers' initial interactional views, as revealed by their written and oral responses to the questions in the first survey/interview guide (Appendix A), is provided below.

The first question asked teachers to identify what role they took on whenever they interacted with students engaged in inquiry science activities. Instead of focusing specifically on the teacher-student interactional dimension of inquiry, most teachers (9 out of 15) described their role in terms of the adoption of general teaching strategies that did not specify any particular forms of verbal or interactional behavior. The most commonly mentioned teaching strategies were transmission of key science concepts and information, provision of hands-on materials, fostering student engagement, and allowing students to explore and experiment. In contrast, the six remaining teachers provided descriptions that identified specific interactional behaviors:

> Teacher 5: I'm a facilitator in the classroom. When my students are making observations of mealworms, I am roaming around the classroom listening to their group discussions.

> Teacher 6: Facilitator - guiding inquiry, provide materials, general guidance, questioning – facilitating pursuit of their questions.

> Teacher 10: I like to think my instructional role in my classroom is a facilitator of learning. I try to divide my time so that I instruct learning and facilitate learning equally.

> Teacher 13: As the teacher I try to let the students investigate and explore the science centers first, guiding them with questions. After they have had time to form their own conclusions, I then come in as the facilitator and teacher, continuing to question them but also giving information.

> Teacher 15: I am a facilitator. I provide opportunities for students to think and inquire and learn on their own.

> Teacher 11: I ask guiding questions and lead them in making discoveries.

As indicated in the above excerpts, several teachers view themselves as *facilitators* of student learning, a metaphoric label that they use loosely in reference to a form of science teaching wherein their students are offered guidance and leadership while independently answering questions and drawing conclusions. Furthermore, three of the above teachers view questioning as the main verbal means by which to guide and lead their students, and only one teacher defines inquiry-based science teaching in terms of the employment of strategic listening behavior ("roaming around the classroom listening").

Teachers used several labels to describe the role that their students play during science inquiry activities (question 2), including scientists, facilitators, experimenters, model makers, learners, teachers, and active participants. Similar to the previous question, teachers tended to overlook the teacher-student interactional dimension, focusing instead on nonverbal aspects of inquiry-based science instruction. Some nonverbal activities frequently mentioned by teachers were: explore, investigate, observe, use materials, design and conduct experiments, record data, and do observational drawings. Nonetheless, teachers sometimes also included specific verbal behaviors in their descriptions of students' interactional roles, the most common being asking questions which was mentioned by four different teachers. The following quotations illustrate the other types of student verbal activity identified by teachers:

Teacher 13: The students discuss the science concept with their peers and myself.

Teacher 10: Sometimes students explain things to one another.

Teacher 7: [Students] listen and work together.

Teacher 8: Students share ideas.

With the exception of Teacher 7, who associates inquiry-based science learning with listening behavior on the part of students, all of the above teachers define their students' interactional role in terms of speaking activities such as discussing, explaining, and sharing. Furthermore, the teachers' responses tend to focus primarily on the student-student interactional dimension of inquiry, and only Teacher 13 provides a response that addresses the teacher-student dimension more explicitly.

Five teachers were unable to articulate in a specific manner the type of social relationship they sought to establish with their students while implementing inquiry-based activities in their classrooms (question 3). Rather than focusing on interactional aspects of inquiry science instruction, these teachers provided responses in which they described their commonly adopted pedagogical strategies such as using the 5E's instructional model (Bybee, 1997), providing demonstrations, correcting students' misconceptions, reading stories, and transmitting scientific knowledge. Three other teachers provided descriptions of symmetric forms of classroom relationships - partnership, friendship and mutual mentorship. Finally, the remaining teachers emphasized respect, openness and closeness in their relationships with students:

> Teacher 7: I have an <u>open</u>, friendly relationship with my kids.
>
> Teacher 9: Mutual <u>respect</u>, I am <u>open</u> to questions they have...
>
> Teacher 10: I treat my students with <u>respect</u>...so they fell comfortable talking to one another and myself
>
> Teacher 12: <u>Open</u>. They are able to ask any questions...
>
> Teacher 13: Comfortable and <u>close</u> enough with me to share their ideas and communicate their thoughts.
>
> Teacher 11: <u>Intimate</u> relationship.

The above excerpts highlight how several teachers consider the establishment of open, respectful and close teacher-student relationships to be an important requirement for the promotion of a trusting, friendly and positive social climate in the classroom so that students can feel comfortable asking questions and sharing their thoughts and ideas with others while engaged in scientific inquiry.

The teachers also had difficulty comparing inquiry-based and expository approaches to science teaching along the teacher-student interactional dimension (question 4). When asked to compare the types of social roles and relationships found in inquiry science lessons and lectures, most teachers simply claimed not to lecture at all or were unable to articulate interactional differences, focusing instead on general inquiry-based teaching practices such as circulating around the room, promoting group work, sitting on the floor to discuss, and writing students' ideas on the board. Only two teachers were able to provide responses that hinted vaguely at differences in terms of teacher-student interaction:

> Teacher 3: In a more traditional way such as lecturing, students have <u>less of a</u> <u>role</u> and the teacher has <u>most of the responsibility</u>.

> Teacher 11: In a more traditional science teaching, I am <u>leading</u> and they [students] are <u>listening</u>.

In both excerpts, teachers suggest in a very vague manner that teacher-student interaction tends to be more asymmetric in traditional forms of science teaching (compared to inquiry-based science teaching), that is, in lectures the teacher has a relatively higher social status than students, being the person primarily responsible for the science learning process while students are assigned more passive and subordinate roles such as listeners.

Ten teachers thought that the classroom roles and relationships assumed by them and their students varied during inquiry science lessons (question 5). However, only four of these teachers were able to articulate even in vague manner what kind of social variations occurred during inquiry science lessons:

> Teacher 5: I think there are times the instruction is more guided than others.

> Teacher 8: Sometimes I may lead more than in other lessons, especially if I need to guide discussion more closely than in other lessons.

> Teacher 12: Sometimes there is a leader, and then there are just partners...

> Teacher 14: The teacher can be the expert or a guide or a learner even. The students can be those as well.

As can be seen, the first two teachers point out that the amount of guidance or leadership they offer to their students vary depending on what particular inquiry lesson and what particular portion of an inquiry lesson (e.g., whole-class discussion) is being implemented. In contrast, the other two teachers list a number of interactional roles (leader, partner, expert, guide, and learner) assumed during inquiry. However, the above responses are largely limited to claims of interactional variation, providing little (if any) information about the specific moments or activities within inquiry science lessons in which such variations supposedly take place.

In question 8, teachers were asked to identify interactional or communicative abilities they considered to be essential for successful inquiry-based science teaching at the elementary school level. The teachers were grouped into three different categories depending on whether their responses were considered to be mainly cognitive (contained interactional abilities related to the thinking or logical aspects of inquiry), socio-emotional (contained interactional abilities related to the emotional and social aspects of inquiry), or cognitive-socio-emotional (contained a mixture of both cognitive and socio-emotional interactional abilities). Six of the teachers provided cognitive responses such as:

> Teacher 1: <u>Not to tell an answer</u> but allow exploration and failure.
>
> Teacher 7: Know <u>how much to teach</u>, when to <u>let the kids figure it out</u>, and know <u>how to ask good questions</u>.
>
> Teacher 14: <u>How to question and guide</u> the students to developing ideas that work.

As illustrated above, cognitive responses were concerned primarily with elementary teachers' ability to encourage and support the development of students' scientific ideas through skillful use of instructional strategies such as questioning, withholding answers and allowing students to figure out answers on their own (as opposed to telling students what the right answers are).

In contrast, only three teachers emphasized socio-emotional abilities in their responses:

Teacher 9: Patience, and listening skills.

Teacher 13: Patience, encouragement, excitement, and listening skills.

Teacher 15: The ability to let go of the control of the students' learning, passing the torch to each of them.

Two of the above teachers provided responses concerned primarily with the management of emotional aspects of classroom inquiry through skills of patience, listening, encouragement and excitement (rather than focusing on students' emergent ideas). Likewise, the third teacher focused on the social aspect of inquiry (instead of student cognition), resorting to the metaphor of "passing the torch" to convey the need for elementary teachers to able to share control over the science learning process with their students.

The six remaining teachers attended to both cognitive and socio-emotional teaching abilities by providing responses such as:

Teacher 2: Empathy, good questioning skills, caring, common sense, honesty, and perseverance.

Teacher 6: Letting go of control a little bit. Question phrasing – meaningful. Patience to give students time to think.

Teacher 10: Good listener, encouraging, able to ask questions without giving too much information that can change student thinking.

The above teachers highlight both support of student cognition and socio-emotional classroom management, combining cognitive skills such as questioning and common sense with socio-emotional abilities such as being patient, listening, and caring. In doing so, these teachers acknowledge that inquiry-based science learning entails both logical and emotional processes which must be simultaneously managed by skillful elementary teachers.

Question 7 asked teachers to identify interactional skills they thought they lacked (i.e., their interactional inabilities) and to describe previous difficulties interacting students engaged in scientific inquiry. Like in previous questions, many teachers overlooked the teacher-student interactional dimension, focusing instead on general and nonverbal pedagogical issues such as their perceived lack of science content knowledge, inability to evaluate students' developing knowledge, difficulties drawing connections among instructional activities, problems with time management, and difficulty handling unexpected results. The most commonly self-identified interactional inability was allowing students to control their own learning, which was mentioned by four teachers:

> Teacher 3: I sometimes have difficulty 'standing back' and letting students have ownership/control.
>
> Teacher 7: Sometimes it's hard to know when to stop teaching and let the kids figure it out.
>
> Teacher 8: Sometimes I may be too controlling when I actually need to step back.
>
> Teacher 15: Weakness: leading more than I need to and not allowing full discovery.

A common thread running through all of the above responses is that it is challenging for many elementary teachers to share control over the learning of science with students and to promote a sense of ownership among students. Such comments highlight that it is no easy task for teachers to stop teaching science concepts directly and to avoid being excessively leading during classroom inquiry.

Other interactional difficulties found in the teachers' surveys were questioning students with lower abilities, communicating with students who are overexcited or who have a short attention span, keeping younger students focused and on-task, and not providing students with the right answers. It must be pointed out that the teachers tended to report socio-emotional inabilities more often than difficulties in dealing with student cognition. Such a trend suggests that the management of socio-emotional aspects of inquiry-based science instruction (e.g., sharing control with students) tends to be more challenging for elementary teachers than handling issues related to student cognition (e.g., the use of questioning to guide students' emergent ideas).

The teachers' responses also revealed what they considered to be their interactional strengths (question 6). The teachers' self-identified cognitive abilities included questioning, facilitating, responding and listening skills, and allowing students to ask questions. Overall, teachers tended to focus on cognitive skills more often than on socio-emotional abilities, which were mentioned by only two teachers:

> Teacher 8: I encourage learning.
>
> Teacher 13: I encourage my students while at same time sparking their interest and making them excited about the lesson.

Unlike the other teachers who claimed to have strong cognitive skills, both of the above teachers identify motivational abilities (encouraging students and promoting their interest and excitement) as their interactional strength. Such abilities enable the teachers to manage the socio-emotional aspects of their students' inquiry experiences (as opposed to facilitating their students' emergent understandings). This tendency to report abilities related to the management of student cognition is consistent with my previous interpretation of teachers' self-reported inabilities as being indicative of the challenging nature of socio-emotional classroom management.

Teachers' Emergent Interactional Views

This section tracks the evolution of teachers' interactional views while taking part in the professional development activities offered from the second to the ninth day of the SMIT'N summer institute. The text is divided into eight separate subsections, each focused on how teachers' views related to a particular aspect of teacher-student interaction -- teachers' questions, discourse structures, questioning approaches, hedges, reactive behaviors, personal pronouns, directives, and poetic language -- developed during the morning expert instruction sessions and afternoon collaborative assessment sessions. In each subsection, interactional views expressed by the teachers orally (while engaged in group discussions and presentations) and in writing (included in their daily reflections and PowerPoint slides) are both described and illustrated.

Teachers' Questions

On the second day of the SMIT'N institute, participants were offered an expert instruction session focused mainly on the social or interactional functions of teachers' questions. During this session, a facilitator presented a PowerPoint slideshow about language-mediated teacher-student interaction, emphasizing that the types of questions that teachers ask provide evidence of their adoption of a particular interactional positioning.   The facilitator described *closed questions* (i.e., questions that have only one possible right answer), *pseudo-questions* (i.e., "guess what's in my head" type of questions) and *display questions* (i.e., right-or-wrong testing questions) as linguistic evidence of teachers' adoption of an authoritative interactional role. By positioning herself as an expert who tests students' knowledge of "the right answers," the teacher establishes an asymmetric authority-novice type of relationship with students. In contrast, *open questions* (i.e., questions with multiple acceptable answers), and *you-questions* (i.e., "what do you think" type of questions) were described as providing evidence of teachers' adoption of a more egalitarian role. By positioning herself as the guide who simply elicits students' prior knowledge and thinking, the teacher establishes a more symmetric teacher-student relationship.

At the beginning of the morning session, the facilitator asked participants to explain how teachers and students are able to establish certain types of social relationships and adopt particular interactional roles (e.g., authoritarian, friendly, formal, informal, symmetric, asymmetric, etc.) without necessarily talking about or explicitly negotiating their social roles and classroom relationships. The following responses were provided by some of the participating teachers:

> Teacher 1: Okay, you wanna build order or a pattern in how you run a particular session or day, so you usually have people doing it in different ways, so
> Facilitator: Ways of doing different things that establish certain
> Teacher 1: Like sometimes in a science class, you talk about the key concepts at the beginning, you may review, so the kids know that at the beginning you're gonna do this, and at the end you're gonna review, so that's one, I mean, one particular way.
> Teacher 6: It's not even related to science, I think, those children come in with the assumption that you are the authority so, I mean, right there that's established, whereas at home that's always challenged.

As can be seen above, the two teachers do not initially view teacher-student interaction as a dynamic process mediated by language use. Instead, Teacher 1 suggests that teachers are able to relate or interact with their students in particular ways by following certain instructional routines or sequences such as introducing key concepts at the beginning and reviewing concepts at the end of classes. In contrast, Teacher 6 proposes that classroom interactions and relationships are possible because teachers' authoritative role is automatically assumed by their students, a notion that she does not consider to be directly relevant to classroom science inquiry. Both Teachers 1 and 6 have difficulty recognizing that teachers and students continuously negotiate, establish, maintain and even challenge their social relationships and roles by addressing each other in particular ways (e.g., asking certain types of questions) while talking about science.

Early in the session, the facilitator encouraged participants to reflect about the social and interactional functions of teachers' questions by asking them to propose possible reasons for the elevated numbers of questions typically asked by teachers while interacting with students in classroom settings. During the ensuing discussion, participants proposed that teachers' questions served several functions including:

Teacher 9: To assess students' understanding.
Facilitator: Right, to know how much they know.
Teacher 1: To keep them with you.
Facilitator: To focus, yes, to keep them focused.
Teacher 7: To get students to interact.
Facilitator: Ok, to encourage them to interact.
Teacher 11: To help them think about things in different ways they might have not thought about before, the guiding questions.
Facilitator: Right
Teacher 1: To compare knowledge that they already have to what you are trying to establish sometimes.

The above participants identify several cognitive functions typically served by teachers' questions, including assessing students' prior knowledge and emergent understandings as well as guiding and focusing students' thinking. In contrast, participants are able to propose only one interactional or social function for teachers' questions, namely to encourage student participation in classroom interactions. This tendency to emphasize cognitive aspects and, to a large extent, overlook the social functions served by teachers' queries suggests that participants' views of the interactional implications of teachers' questions are relatively undeveloped in this early portion of the session.

Throughout the discussion, the facilitator described several interactional issues raised by current research on teacher questioning in order to increase participants' awareness of the social implications of teachers' questions. One such issue was raised by Rowland (2000) who argued that "the questions teachers ask their pupils are not searchlights focused to reveal truth, but traps set to expose [students'] ignorance." Participants were asked to read a short excerpt from Rowland (2000) which provided a very negative account of teacher questioning, emphasizing that teachers' questions (especially their "testing questions") tend to be negatively perceived by students and can potentially harm children for life. In the following discussion, teachers share their reactions to the reading:

> Teacher 1: Can't you put that in a nicer way, like to expose their misconceptions? Because it's not ignorance, it's misconceptions, and boy, in sciences, there is a lot of it. The word ignorance bothers me, I don't think most teachers are trying to show how ignorant their students are.
> Teacher 5: And I don't think your purpose is to expose it, it's to make, you know, make them aware of it.
> Teacher 6: If you think about it in an evaluative way, to figure out what they don't understand.
> Teacher 4: There are situations where sometimes, um, they are humans, and many of the children feel that they know everything about a subject.
> Teacher 1: Exactly
> Teacher 4: It's nice to ask a question every once in awhile that really sparks their thinking because they don't know it and it makes them a little uncomfortable. But it's not exposing their ignorance, it's just broadening their knowledge.
> Teacher 1: Well, and I think that goes back to taking risks, encouraging students to take risk.
> Teacher 4: That's true.
> Teacher 1: Think about something that you think you are absolutely sure about, and then you have to re-evaluate it.
> Teacher 6: Maybe the point of this [text] is that we might think we are trying to find out their misconceptions, but on the receiving end of the question, *Oh my God I don't know what I'm gonna say*, being on the receiving end of it might be perceived differently.
> Teacher 1: Or being embarrassed about saying something that we [teachers] don't approve.

As can be seen above, the participants' initial reaction is to vehemently disagree with Rowland's negative outlook on teacher's questions. Their argument is that, rather than serving an ill-intentioned end such as "exposing students' ignorance," questions asked by most teachers tend to serve beneficial cognitive purposes such as to make students aware of their science misconceptions, help students recognize limitations in their understandings, encourage students to rethink and reevaluate their conceptions, and encourage students to take intellectual risks. However, later in the discussion, Teacher 6 recognizes that, despite teachers' good intentions, their questions can be received in a negative manner by students. Similarly, Teacher 1 argues that teachers' questions can be negatively perceived by students who are fearful of teacher disapproval of their answers. As a result of participating in this discussion, participants seem to become aware of the possibility of teachers' well-intentioned questions having negative interactional or social effects on students.

A second interactional issue to become a topic of discussion was the alleged linguistic "insincerity" of teachers' questions. In the excerpt read by the participants, Rowland (2000) also proposes that "the expectations of pupils is that classroom questions are not genuine requests for information, but public requests for display… in that the enquirer A [teacher] already has the information sought in the question, and the request is for B [the student] to display whether or not s/he already has the information." This issue was brought up by the facilitator while discussing the excerpt with participants:

> Facilitator: Teachers' questions are not considered to be sincere questions.
> Teacher 1: Because students always think there is an answer for them, and you know it.
> Facilitator: And, how are teachers' questions different from when you call someone to ask for information for example? How are the two questions different?
> Teacher 6: Well, [in the case of teachers' questions] there is the assumption that it [the answer] is right or wrong, and *I sure don't wanna be the one to say the wrong answer*.

Teacher 1 recognizes that teachers' questions tend to be perceived as insincere because students' extended experiences with schooling and testing create an expectation that teachers invariably know the answers to their own questions which are asked only for the purpose of testing pupils' knowledge. Similarly, Teachers 6 points out that students tend to automatically assume that there is always a right or wrong answer to teachers' questions, and calling out wrong answers is socially undesirable. By providing such responses, Teachers 1 and 6 demonstrate having developed an increased awareness of the social or interactional aspects of teachers' questions in classroom discourse.

A third interactional issue discussed in the morning session was the effectiveness of asking questions as a strategy commonly used by teachers to promote student talk, participation, and thinking. Using a PowerPoint slideshow, the facilitator presented teachers with excerpts from Nunn (1996) who argued that "although asking questions has been a recommended discussion stimulating technique… [some educators] explicitly recommend against questioning by the teachers because they believe that teachers' questions do not stimulate student thinking and they do not encourage participation. They depress student thought and talk." The following comments were provided by the participants while discussing the excerpt:

> Teacher 1: Some students will shut down if you start asking questions.
>
> Teacher 9: We are not talking about how the students have to answer these questions, like if they are put on the spot and give these answers right away, that I can see, that would depress student thought and talk, but another strategy that teachers use is to have students answer these questions like, and then, and maybe write about it first or talk about it with a partner, and I think in that, in that case, questions can actually encourage talk.

Teacher 1 simply confirms that teacher questioning can in fact have a negative interactional effect on some students, inhibiting their participation and discouraging them from sharing their thoughts. In contrast, Teacher 9 highlights the importance of considering the social or interactional context in which students are asked to answer teachers' questions. Teachers' questions can in fact have a negative interactional effect when students are asked to provide answers individually, without time to prepare or help from peers ("being put on the spot"). Nevertheless, teachers' queries can have a positive interactional effect if students are provided with a more supportive and less threatening social context in which to come up with answers (e.g., small groups).

Later in the discussion, the facilitator sought to increase participants' awareness of specific types of queries commonly asked by teachers in classroom settings such as "you-questions." These were defined by the facilitator as "questions with the second-person pronoun *you* that encourage student to focus on articulating their own thoughts rather than on providing the right answer. After defining and illustrating you-questions, the facilitator started a discussion by asking the following question:

> Facilitator: Where do you think you-questions would be more commonly found within the learning cycle?
> Teacher 5: In the evaluative phase, when teachers evaluate what they [students] are thinking.
> Facilitator: Although, when you evaluate, you are expecting the right answer typically, don't you?
> Teacher 3: Typically, you have children going back to different backgrounds, and you have *Evaluate*, it's when you give your opinion, what you think, that's why they are evaluative questions, because you are evaluating based on your values and your experience.
> Teacher 6: It's like a pre-evaluation, but I think it could be *Engage* and *Explain* too.
> Facilitator: Specially, if teachers are using inquiry, the assessments tend to use you-questions a lot.
> Teacher 7: All formative assessments.

When asked to speculate in what phase of the 5-E learning cycle -- Engage, Explore, Explain, Expand, or Evaluate (Bybee, 1997) -- they expect "you-questions" to occur most frequently, participants immediately identify the Evaluation phase. However, as the discussion unfolds, it becomes increasingly clear to the discussants that the occurrence of you-questions is contingent upon the instructional context in which evaluation occurs, that is, you-questions may occur frequently or not depending on the type of assessment and curriculum adopted by the teacher. Teacher 7 proposes that formative assessments are likely to engender high numbers of you-questions. Furthermore, Teacher 6 points out that it is reasonable to expect teachers to ask you-questions in other phases of the learning cycle such as the Engage and Explain phases. As a result, participants are able to collaboratively create a discourse-centered view of classroom inquiry by predicting, based on their previous teaching experiences, in what particular instructional phases query types such as you-questions are more likely to be asked by teachers.

Another teacher query type brought up by the facilitator was rhetorical questions. In the second half of the discussion, the facilitator asked participants the following question:

> Facilitator: Why do we [teachers] ask rhetorical questions?
> Teacher 6: It may not be rhetorical for everybody, because some people might not know, and then if you do it like, well, I can't even think of an example.
> Facilitator: Is there any advantage? Like to make a statement, why not just make a statement rather than using that question format?
> Teacher 6: It's kinda like keeping them involved.

Rather than providing a linguistic definition, the facilitator asks participants to identify possible interactional purposes for teachers' rhetorical questions. At first, Teacher 6 proposes that students' perceptions of rhetorical questions may vary depending on their background or prior knowledge but is unable to provide an illustrating example. However, when the facilitator asks for possible reasons why teachers often ask rhetorical questions rather simply stating their points directly, Teacher 6 is able to identify creation of student involvement as an interactional function of teachers' rhetorical questions, thus demonstrating that she has developed a higher level of awareness of the social dimension of teacher questioning.

The social or interactional functions of teachers' rhetorical questions were also discussed in the third day of the SMIT'N workshop. During an inquiry immersion session on genetic inheritance, Facilitator 2 asked the question "*what about some of the traits like intelligence, can you imagine how many genes would be involved?*" This query was later identified as being a rhetorical question by the Facilitator of the afternoon collaborative assessment session who argued that "*you* [Facilitator 2] *didn't expect an answer, you didn't provide an answer, so this was clearly a rhetorical question*." The discussion below followed:

Facilitator 2: Yeah, I was just thinking that, do we use rhetorical questions when we don't think, you know, we are trying to like probe the unknown? I mean, I don't know. Because I don't, I would not expect anyone, you know, me or anyone, or geneticists to be able to answer that.

Facilitator: Is it worth asking that [rhetorical question]? What are you trying to accomplish?

Teacher 1: Yes, and I will say why. Because the way you [Facilitator 2] teach makes me feel like I'm not so stupid, because you ask questions and then you sort of go *why? Well, nobody really knows the answer to this*… it makes you feel less, a rhetorical question makes you feel like *okay, I'm there, nobody else has the answer to this either*.

Facilitator3: I think it gives a better idea about science, that scientists don't, aren't special people that know it all.

Teacher 1: That's the other thing, we don't know it all, scientists don't know it all.

Facilitator 3: They are still working on it.

Teacher 14: And it's that wow factor where all of us reading that, *can you imagine how many genes are involved in just intelligence? Wow*, and maybe someday we will know that, maybe someday, and kinda give those kids, um, a direction, it gets them a little bit interested, I know when they feel like they are questioning things that maybe there isn't an answer to yet but they might be the one to fill for that, or they might, or they might then have that direction of, *I wanna find out, I wanna find out what genes control your intelligence*. I know, especially knowing my students, there are several in my school that would feel like this was their challenge, like to find out what, you know, what genes controlled what, that would interest them so much, so maybe a rhetorical question like that, I mean, some rhetorical questions go without being said, but something like that, whether there is that wow factor, *wow that's um, it would be amazing to find out, or it would be amazing to research, or would be amazing to be involved*.

Teacher 1: Or at least to read more about that.

Teacher 14: Or to read more, yeah.

Facilitator 2 starts off the above discussion by agreeing with the Facilitator's classification of her query as a rhetorical question. There was indeed no expectation on her part that someone in the room would be able to provide an answer to her question, not even biology experts such as geneticists. Furthermore, Facilitator 2 raises the possibility that rhetorical questions can serve cognitive functions such as probing beyond what is currently known by scientists. When the Facilitator asks about possible social or interactional functions served by teachers' rhetorical questions, Teacher 1 proposes that, by asking questions that scientists have not been able to answer, instructors can help students develop less negative feelings about not knowing all the answers ("I'm not so stupid"). Moreover, such questions narrow the social gap among students, teachers, and scientists, thus putting everyone on more equal grounds ("okay, I'm there, nobody else has the answer to this either"). This view is supported by Facilitator 3 who then adds that rhetorical questions highlighting what is unknown to science can help improve students' view of scientific activity and scientists ("scientists aren't special people that know it all"). Finally, Teacher 14 adds that rhetorical questions can also serve a motivational function by helping students to realize how amazing it would be to find out the answers to such questions (i.e., creating "the wow factor") and by encouraging them to research and read more about the topic at hand. As the discussion unfolds, participants and facilitators are able to co-construct a view of teachers' rhetorical questions as multifunctional discursive devices that serve both cognitive and social ends.

Toward the end of the morning session of Day 2, the facilitator played a video-recording of Mrs. Neuhall, a first-grade teacher, while implementing an inquiry science lesson on the properties of air. The video is entitled *The Properties of Air in First Grade Science* and is available online (Prentice Hall, 2007). At the beginning of the lesson, Mrs. Neuhall facilitates a whole-class discussion, opening with the question "how do you know if something is real?" When her student Jessica volunteers to answer the question, Mrs. Neuhall shows her a silver spoon and then rewords her query: "Well, Jessica, is this real? [Jessica nods her head affirmatively] how do you know?" Jessica stares blankly for a few seconds and when the Mrs.

Neuhall follows up with the query "what is it?" Jessica shrugs her shoulders and replies "it's a spoon." In the excerpt below, the facilitator and teachers discuss the video-recording:

> Teacher 8: To me, it seems that's one of those "read my mind questions" especially when she kept asking poor Jessica, *Jessica what am* I *thinking about?*
> Facilitator: Right, it could be anything really, what's something real? I mean, it could be anything, I think you are right, it's definitely one of those pseudo-questions.
> Teacher 6: I think that the lack of answers is because they are like, *well, oh yeah, it's so obvious, it's a spoon* [laughs].

Teacher 8 criticizes Mrs. Neuhall's line of questioning at the beginning of the lesson, arguing that a query such as "how do you know if something is real?" encourages Jessica and other students to try to guess what the teacher has in her mind. The facilitator then replies with an agreeing comment, emphasizing the vagueness of Mrs. Neuhall query does indeed render it the status of a "pseudo-question." Lastly, Teacher 6 proposes that the obvious nature of Mrs. Neuhall's question can possibly explain the apparent lack of responses that her students seem to provide. In other words, Mrs. Neuhall is asking the obvious and for this reason is unable to promote student participation and engagement in the discussion. It must be noticed that both teachers focus on the interactional impact of Mrs. Neuhall questioning, thus providing evidence of their increased sensitive to and ability to articulate the social atmosphere of the video-recorded classroom.

Discourse Structures

On Day 3 of the SMIT'N institute, professional development activities were focused on discourse structures commonly found in classroom settings. A facilitator gave a PowerPoint presentation emphasizing that teachers tend to become authoritarian while interacting with students by claiming superordinate speaker rights such as asking questions, evaluating students' contributions as being right or wrong, interrupting students and ignoring topics introduced by students. In contrast, students frequently hold subordinate speaker rights such as providing responses to teachers' questions and prompts. The facilitator also provided teachers with definitions and examples of a variety of discourse structures currently described in the science education literature, including IRE, IRF, IR, IRFRF, and RR interactional patterns.

In early portions of the morning expert instruction session, the facilitator and participants had an extended discussion about the differences between the more authoritarian IRE and the less authoritarian IRF interactional patterns. Initially, some teachers tended to view IRF as being more dialogic in nature:

> Teacher 4: This one [IRF] seems more like a conversation in the sense that is not like a quiz show, because you could say, you could extend their thought, which I think pulls children into the conversation, they feel like they added something and then you can take it [the student response] anywhere you want.

In her response, Teacher 4 argues that IRF enables teachers to extend students' responses, a move that can encourage student participation by highlighting the significance of students' contributions to the ongoing discussion (as opposed to creating the impression of "a quiz show" in which students are constantly being tested by the teacher's display questions). Later in the discussion, the facilitator asked participants to predict where in the learning cycle they expected IRE and IRF interactional patterns to occur more frequently:

> Teacher 6: In the video we were watching yesterday, I mean this kind of thing was going on, and we were calling this prompting or leading, I mean, and there are so many, I mean, we are like flipping through it [the handout], we were like *what do you call that? What do you call that?* Evidential questions, and they kind of seem the same, and now we are thinking something else, uh, this kind of, you know, not this topic of course, but that kind of conversation, that kind of, you know, give and take was going on at the, you know, towards the end of the lesson.
> Facilitator: Where do you think, if you think of the learning cycle, where do you predict the IRE would be in the learning cycle?
> Teacher 6: In Explain
> Teacher 1: I think it could also be in Engage, I can see it happening in both.
> Teacher 4: It could also be in Elaborate, you take it and display it to the whole group.
> Teacher 6: I think the IRF does seem like Elaborate to me.

Teacher 6 starts off the above discussion by pointing out that, in the previous day of the institute, her group noticed and struggled to describe the three-part teacher-student interactional pattern while examining a video-recording of an inquiry science lesson. When asked to identify phases of the learning cycle wherein the IRE pattern can possibly be found, the participants seem to disagree. Teacher 6 argues that IRE sequences will tend to occur in the Explain phase (when the teacher normally introduces science concepts and terminology), whereas IRF turn taking is more likely to occur in the Elaborate or Extend phase (where teachers typically encourage students to draw connections and to apply the learned concepts to different situations). In contrast, Teachers 1 and 4 propose that IRE sequences can also happen in the Engage and Elaborate phases of the learning cycle. The three participants' apparent inability to articulate plausible justifications for their claims suggests that their views of discourse structures are relatively undeveloped.

In order to illustrate the IRF pattern, the facilitator had participants examine the transcribed recordings of an inquiry science lesson wherein a teacher asks the question "what are some factors that affect rate of dissolving?" When a student provides the response "the volume of the solvent," the teacher reacts by saying "yes, to be more specific, we are talking about size of solute, surface area." For the complete transcriptions see Chin (2006). This particular teacher-student interaction was mentioned by the facilitator and participants while discussing the Evaluation/Feedback distinction currently made in the science education literature:

> Facilitator: The distinction between evaluation and feedback is not always clear and is interpretative, and that's something we're gonna to have to ponder about.
> Teacher 1: Because I can see that [the transcribed teacher feedback] as evaluative, if you ask me why, well, because he [the transcribed teacher] is checking to see
> Teacher 6: And then adding to it [the transcribed student response], which made me think Elaborate, the Elaboration part.
> Facilitator: And also some responses can be both, I've seen a couple of cases where the teacher is doing, to me, the impression I had was that she was evaluating and

also providing feedback, so that dichotomy doesn't always work, that's something we need to reflect about, how you make the two different.

Teacher 6: Do we need to make them different?

Facilitator: Do we need to make them different? That's a good question too.

When the facilitator points out that the difference between teacher evaluation and teacher feedback can be unclear and contingent upon analytical interpretation, Teacher 1 immediately reacts by arguing that she considers the transcribed teacher comment "yes, to be more specific, we are talking about size of solute, surface area" to have an evaluative connotation. Teacher 6 seems to be recognizing that by prefacing his reactive comment with the affirmative "yes" the teacher provides a positive evaluation of the student idea. This view is supported by Teacher 6 who adds that the teacher comment also serves an elaborative function, that is, the teacher extends the student's idea by presenting "size of solute" or "surface area" as having a higher degree of semantic or referential specificity than "volume of solvent." After the facilitator highlights the potential multifunctionality of teachers' reactive comments (i.e., the possibility of teachers' comments serving both as evaluation and feedback), Teacher 6 begins to question the need to make the Evaluation/Feedback analytical distinction. Rather than arguing either in favor or against making the evaluation/feedback distinction, the facilitator adopts a neutral stance, encouraging teachers to consider this issue in their own discourse analyses.

Later in the morning session, the facilitator presented a PowerPoint slide on I-R couplets, an interactional pattern in which the teacher purposively avoids evaluating the students by skipping the third move of IRE sequences (Figure 4.1). Transcribed recordings of an inquiry science lesson on the burning of wax candles were included on the slide in order to illustrate the interactional nature of IR couplets. See Oliveira et al (2007a) for complete transcripts and extensive discourse analysis of the candle classroom inquiry.

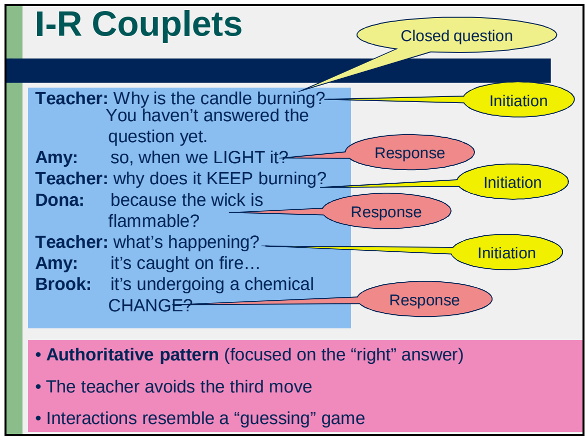

Figure 4.1 - PowerPoint slide on IR couplets presented by the facilitator.

While discussing the slide shown in Figure 4.1, the facilitator encouraged participants to comment on the transcribed teacher-student interactions, focusing specifically on the non-evaluative verbal strategy adopted by the teacher during the candle classroom inquiry:

Facilitator: What's your impression about this [transcript]?
Teacher 6: I can see there continuing to be lots of confusion on the part of the student.
Facilitator: Do you think this is guiding, like you are supposed to do when you teach through inquiry? What's the role of evaluation when you think you are expected to guide students? Is evaluating part of being a guide?
Teacher 1: Well, this is one of those questions where the kids are trying to guess what she [the teacher] has in mind.
Teacher 6: It's like going in a circle, it's like there is no point, it's confusing.
Facilitator: That's something we need to ponder about, whether do we really want to stop evaluating altogether? Is that what we want to do to guide?
Teacher 4: If the teacher were to say something like *keep going*, or *try to look at that in a different way*, is that an evaluation?
Facilitator: I don't know, what do you think?
Teacher 6: It gets more guiding, if you say *keep going* that kind of gives the impression that you are on the right track, *you're getting warm* [laughs].

Teacher 6 has a negative view of the transcribed teacher's avoidance of evaluative moves, considering it to be pointless and a potential source of confusion to students. Similarly, Teacher 1 suggests that, by not evaluating, the transcribed teacher ends up encouraging students to engage in a "read-my-mind" type of verbal interaction. Although not explicitly articulated in her suggestion, Teacher 1 seems to recognize that the transcribed teacher's failure to provide explicit evaluations is likely being interpreted by the students as a potentially negative evaluation of their responses, thus encouraging them to continue to offer responses while seeking to elicit a more explicit form of evaluation from the teacher. Furthermore, the facilitator's questions encourage Teacher 1 to reflect about the evaluative nature of comments such as "keep going" and "try to look at that in a different way;" both of which are considered more guiding by Teacher 6. Teachers 1 and 6 seem to suggest that, rather than adopting a completely neutral stance toward the students' ideas and responses, the teacher should have responded to students with fairly vague and evaluative commentary that could have provided them with a sense of direction (e.g., "you are on the right track"). As the discussion unfolds, it becomes increasingly apparent that Teachers 1 and 6 are collaboratively developing a view of "guiding" as an instructional practice wherein the teacher employs relatively vague and yet evaluative language while talking to students.

Later in the discussion, some participants pointed out that teachers can also convey particular evaluative attitudes or stances to students through nonverbal communicative channels:

> Teacher 11: I was just thinking this kinda, it's taking out the nonverbal communication part of it, because I'm thinking if a teacher gives them a look like, you know, a look like the students are on the right track, that's almost like feedback.
> Teacher 1: You do a lot of gestures.
> Teacher 11: Yeah, gesturing.
> Teacher 6: Intonation.
> Teacher 11: Exactly, it's all the, you know, reading it in a paper doesn't really explain how someone is actually saying that, you say a lot more than just the words you say.
> Teacher 6: And gestures.
> Facilitator: I agree with you, the problem with transcripts is that you can't tell, sometimes you can give feedback by your face expression, you deal with students everyday, so they know you, you know them too, so just your face, they know
> Teacher 11: Right, they know what you're thinking
> Facilitator: They start reading you really, they can tell whether they are right or wrong, so you don't need to verbalize it for them to catch that, that's why is difficult to be neutral and to avoid evaluating because we do that even with our body.
> Teacher 11: Yeah, I am sure they that can pick up on that.

The above discussion begins with Teacher 11 pointing out that it is possible for teachers to provide evaluative feedback to students without necessarily uttering any words at all (e.g., "a look like the students are on the right track"). Her view is supported by Teachers 1 and 6 who also mention teachers' intonation and gestures as possible nonverbal means of conveying evaluative attitudes to students. Teacher 11 is also able to eloquently point out the analytical limitations of transcribed recordings which tend to focus mainly on verbal aspects of teachers' communicative practices ("you say a lot more than just the words you say"). The facilitator then reinforces Teacher 11's view, highlighting that teachers do not necessarily need to verbalize their evaluations to students in order to let them know whether they are on the right track or not. Such evaluative information can also be transmitted through nonverbal forms of teacher-student communication such as face expressions and body movements. It must be noticed that the participants are developing a view of "guiding" as a form of classroom interaction that requires teachers to do more than simply remain neutral by avoiding overtly evaluative language. Instead teacher guidance is being articulated as a complex instructional practice wherein the teacher is able to make effective use of verbal and nonverbal communicative channels in order to adopt a sufficiently non-evaluative interactional positioning in relation to students.

Toward the end of the morning session, participants watched and discussed a video of an instructor and a group of four elementary students investigating what happens when objects (a plastic spoon, a cloths' pin, a metal paperclip, and a metal key) are dropped into a bowl of water. During the investigation the instructor continuously asked students to predict and then test their predictions. For instance, early in the video the instructor hands a plastic spoon to a student and then asks "what do you think it will happen when we drop this spoon into the water?" When the student says "I think it's gonna float," the instructor repeats his answer "He thinks is gonna float." After observing that the plastic spoon indeed floats in water, the instructor grabs a wooden cloth's pin, hands it to a second student and then asks "what do you think will happen when we drop a cloth's pin into the water?" When the student replies "I think it will sink," the instructor says "okay" and then directs the student to drop it into the water bowl. The video is commercially available and can be found in the CD-ROM that accompanies Martin (2006). The discussion below is about the video-recorded interactions:

> Facilitator: What is your impression so far? Anything interesting that you observed?
> Teacher 9: Well, the first two times that she [the teacher] had them make predictions she didn't give any feedback, and then the girl with the paper clip
> Facilitator: Right, I noticed that too, the first two times she only said *okay*, she didn't say anything, she was absolutely neutral.
> Teacher 7: I was gonna say the same thing, I felt she didn't talk about what they were made of, or why they were, I don't know if she is gonna get to it at the end, but at the end it might be confusing.

Teachers 7 and 9 agree that the video-recorded instructor is not providing students with any type of feedback, an observation that is confirmed by the facilitator. Instead of following up on issues being raised by the students (e.g., "what materials the objects were made of"), the instructor simply acknowledges their responses by uttering neutral comments such as "okay" or repeating their ideas verbatim. After showing a few more minutes of the video, the facilitator stops it and then asks participants to share their reactions to the video:

> Facilitator: What's your impression so far?
> Facilitator 2: IR IR IR? She is not giving feedback at all, right?
> Facilitator: Um, she is still making the third move though, right? You could argue that the *okay* is the third move, it's neutral feedback, I guess, what do you think? What would you argue, it's IRF or IR?
> Teacher 6: It's not F.
> Teacher 1: I don't think it's IRF.
> Teacher 4: I don't think it's IRF either.
> Facilitator 2: In my head, feedback is when you are giving some kind of information, you are getting them to think.
> Teacher 8: And her body language doesn't give anything away either, so this, I have no clue.

Facilitator: Right, I think that's another indication that she is really well trained in this, not even her body, intonation, nothing, she is giving no information at all, she is neutral. And, is this something that we want to do when we are doing inquiry or not, what do you think?

Teacher 6: I think you could a little bit, or like in the Explore or maybe even Engage but, I mean, if it goes on too long, it's like *what are you doing?*

When Facilitator 2 proposes that there are no Feedback moves and the video-recorded interactions are following an IR discourse pattern, the Facilitator argues that teacher comments such as "okay" can also be considered a neutral form feedback and then asks participants whether they consider the video-recorded teacher-student interactions to have an IR or IRF structure. Teachers 1, 4 and 6 all agree with Facilitator 2's view who then offers a definition of Feedback as a move in which the instructor provides students with scientific information or encourages their thinking. When Teacher 8 adds that no feedback or evaluation is being transmitted through nonverbal communicative channels either ("her body language doesn't give anything away either"), the Facilitator asks whether adopting such neutral interactional positioning in relation to the student is appropriate when teaching science through inquiry. In response, Teacher 6 argues that being interactionally neutral and providing no feedback to students can be appropriate in earlier phases of classroom inquiries (Engage and Explore phases), but such discursive practices can potentially confuse students and for this reason should not be overused by instructors. As the discussion unfolds, participants and facilitators collaboratively clarify what can be considered Feedback moves, highlighting the importance of such discursive practice to inquiry-based science teaching.

While still discussing the video, the facilitator asked participants whether they considered the instructor's performance shown on tape to be consistent with what is referred to in current science education reform efforts as guiding students engaged in classroom inquiries:

Facilitator: Is she [the video-recorded teacher] being a guide like what the standards are calling for? Do you call her behavior as guiding, based on the portion that you saw?
Teachers: No, not really.
Facilitator: So, what makes a guide? What does it take?
Teacher 8: A guide helps further your thinking, and facilitate us, she is not, she is really tipping it back on them, even though she is dropping crayons.
Teacher 4: A guide adds vocabulary to your knowledge, so while they are trying to investigate, you are adding, you are just building on what they know.
Facilitator: How about feedback? Does a guide give feedback?
Teachers: Yes.
Facilitator: Does a guide evaluate?
Teachers: Yeah, I think so.
Teacher 6: I'm thinking of first graders, like they get misconception in their head, and they learn it wrong, and they cannot unlearn it, I think it's really risky to go on like this, I mean, and I can name students in my class that would tell you the wrong stuff, and they will just be convinced no matter what you did, it's hard to unlearn.
Teacher 15: I think she could give them some feedback that like allow them, to help evaluate themselves and then rather than holding in the evaluation, you know, just something in response from her to help them think more thoroughly so that they can start evaluating themselves, but [on the videotape] it was just sort of left at that, and so they are just kind of shooting upwards and there is really no interconnection happening.

When participants respond that they do not consider the instructor's performance captured on tape as "guiding students," the facilitator encourages them to identify discursive strategies that teachers should necessarily adopt while interacting with students in order to position themselves as guides. At this point of the discussion, there seems to be a consensus among participants that teachers must necessarily provide students with both feedback and evaluations in order to be able to effectively guide pupils. Furthermore, Teacher 6 describes her previous instructional experiences dealing with students' misconceptions in order to illustrate how evaluating students is a necessary part of being a guide. Her suggestion seems to be that, without resorting to explicit evaluations, instructors might not be able to effectively address students' misconceptions related to science. Finally, Teacher 15 argues that instructors should concentrate their efforts on providing students with feedback that can enable them to evaluate themselves and interconnect science-related ideas rather than simply withholding evaluations from students. Adoption of the latter practice by the video-recorded instructor encouraged students to start "shooting answers upwards without making any interconnections." The above discussions indicate that participants developed a view of evaluation as being necessarily part of the discourse of a guide (as opposed to viewing guiding and evaluating as mutually exclusive practices).

Questioning Approaches

On the fourth day of the SMIT'N institute, participants were introduced to a variety of questioning approaches, strategies and techniques commonly utilized by teachers in both traditional and constructivist instructional settings. In the morning session, a facilitator gave a PowerPoint presentation, highlighting the difference between more authoritative (or evaluative) questioning and less authoritative (or constructivist) questioning. The former was described by the facilitator as an instructional mode in which the teacher continues to ask questions in order to evaluate what students know and to lead them to say the right answers through convergent discursive strategies such as cued elicitation, retrospective elicitation, Socratic questioning, verbal jigsaw, verbal cloze, and association of words and phrases. In contrast, less authoritative forms of questioning are focused on eliciting, encouraging and supporting student thinking through more divergent discursive techniques such as pumping, reflective toss, constructive challenge, semantic tapestry, multi-pronged questioning, multi-modal thinking, focusing and zooming, and framing.

At the beginning of the PowerPoint presentation, the facilitator described and illustrated cued elicitation to participants, providing them with a short transcription of a science lesson in which a teacher asks her students how Galileo was able to measure time without using a watch.

When her students provide no response, the teacher starts providing clues such as "*You've got it, I've got it. What is it? What could we use to count beats? What have you got?*" Still getting no response from her students, the teacher then resorts to a physical demonstration "you can feel it right here [pointing to her wrist]," leading a student to say "*pulse*." See Edwards and Mercer (1987) for the complete transcripts and a detailed discourse analysis. After reading the transcript out loud, the facilitator asked the following question:

> Facilitator: Do you think that's authoritative?
> Teacher 6: It's the *guess what's in my head* thing.
> Facilitator: Right
> Teacher 6: That's just, it keeps coming, that's just obvious to me, *guess what's in my head*.

When the facilitator asks participants whether they consider cued elicitation to be an authoritative form of questioning, Teacher 6 immediately points out that the transcribed teacher is encouraging her students to guess the answer that she has in mind. In other words, the transcribed teacher is asking a series of "pseudo-questions" and is providing clues in order to help students read her mind, thus establishing herself as a knowledgeable authority who has the interactional right to withhold answers (rather than stating them directly). It must be noticed that Teacher 6 seems unable to articulate the authoritative interactional implications of the transcribed teacher's approach, thus suggesting that her views of questioning are relatively undeveloped.

Early in the presentation, the facilitator also provided participants with a PowerPoint slide on retroactive elicitation (Figure 4.2). This authoritative approach to questioning was illustrated by a short transcript of a science lesson on the swinging movement of pendulums wherein a teacher asks a student named Jonathan to repeat his response to the question "*what* *makes a pendulum swing in a downward direction?*" For more information about the pendulum lesson see Edwards and Mercer (1987).

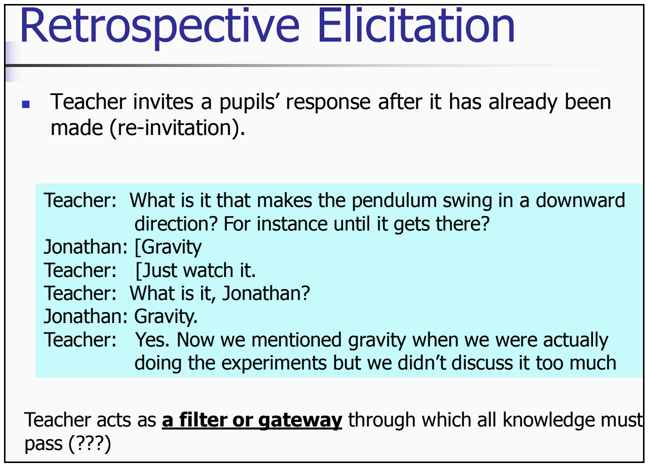

Figure 4.2 - PowerPoint slide on retrospective elicitation presented by the facilitator.

The excerpt below shows participants and the facilitator while discussing the transcribed interactions shown on the slide as well as Edwards and Mercer's (1987) interpretation of the transcribed teacher's retroactive elicitation move as a means of adopting an authoritative interactional positioning ("the teacher acts as a filter or gateway through which all knowledge must pass"):

Facilitator: The interpretation of the author is that this is authoritative because the teacher is establishing herself as a filter or gateway through which all knowledge must pass. So this gets to that notion of intention, I think the author is establishing a negative intention to the teacher, because there are many other explanations to why the teacher asked that question. What's a possible, a different explanation?
Teacher 6: Just didn't hear it.
Facilitator: Exactly, so this is kind of questionable because it depends on whether the teacher really had that intention to filter the information or not. But the author argues that this is authoritative, this is a teacher transforming something that was spontaneous to something that was elicited and approved by teacher, this has got the teacher stamp, this is good, a good idea.
Teacher 1: Sometimes you do that too when you're trying to get to the quieter children who may not have a chance to respond, like Jonathan who is left out all the time.
Facilitator: Right
Teacher 6: Or to make sure everybody hears it.
Teacher 11: That's what I was thinking, make sure everybody hears it by saying it again.

Teacher 6: Instead of being the megaphone, you know, to make sure everybody hears it.
Facilitator: Right

The facilitator starts the above discussion by arguing that the authors' interpretation of the transcribed teacher's request for a repetition as a move aimed at adopting the interactional positioning of a "filter" or "gateway" for knowledge seems to be based on an assumption that the teacher is ill-intentioned. Furthermore, the facilitator describes the authors' analytical interpretation in terms of a stamp metaphor, that is, the authors seem to argue that the teacher's request for Jonathan to repeat his response serves primarily to provide her with a chance to discursively mark his answer as a "good idea" and as being officially "elicited and approved by the teacher." When asked to provide alternative explanations to why the teacher asked Jonathan to repeat his response, participants offer several replies, including "[the teacher] just didn't hear it [Jonathan's answer]", "[the teacher is] trying to get to the quieter children," and "[the teacher wants] to make sure that everybody hears it [Jonathan's answer]." It must be noticed that all of the participants' explanations are based on the assumption that the transcribed teacher has positive intentions (i.e., helping students) rather than negative ones as assumed by the authors (i.e., to adopt an authoritative interactional positioning in relation to the students). Such explanations indicate that the participants have developed a view of questioning approaches as being contingent upon what analysts consider to be the nature of teachers' intentions.

In the second half of the morning session, the facilitator played several video clips recorded during the classroom implementation of a four-day, inquiry-based science lesson on earthworms. The video clips provided participants with snapshots of Mr. McKnight's interactions with a group of fourth graders while observing, exploring and collecting data on the habits of earthworms (e.g., their body movement, preferred environments, etc). For the videos and more information about the earthworm inquiry lesson see the companion CD entitled "*Visit an Inquiry Classroom*" (Peters & Stout, 2006).

The first video clip was recorded at the beginning of the inquiry lesson, and it showed Mr. McKnight facilitating a whole class discussion before he asked his students to observe and explore earthworm behaviors. In this discussion, Mr. McKnight asked students a series of yes-or-no questions: "*Maybe they* [earthworms] *like dark because it is usually cooler? So, they usually try to get to dark areas? So, maybe that's like a habit for them? A way they usually behave? Do you think earthworms have habits? Do they have ways they like to do things? Even though they are just a dumb worm? Are they smart enough to have habits?*" Mr. McKnight then ended the discussion by stating "*Yeah, they do, they have ways they like to things, they like moist areas over dry areas, they prefer dark areas over bright areas*." In the excerpt below, the facilitator and participants collaboratively analyze Mr. McKnight's questioning approach:

> Facilitator: What kind of questions was he asking? I thought I saw a few *you* questions there. Did you [Teacher 3] say leading questions? That's something I had in my mind too.
>
> Teacher 3: I don't know if that's the terminology, I am trying to think about the things you told us, but I think he was really trying to get some information from them
>
> Teacher 5: About what would be the next step.
>
> Teacher 3: Right. I thought it was the beginning, he was taking some things that they knew and leading them to what they were gonna try to do as their inquiry went on.
>
> Facilitator: I thought the same, especially when he is talking about behavior, whether worms have behaviors or not, because he only asks yes or no questions, he doesn't give them a chance to express anything, except yes or no. Don't you think that looks a lot like Socratic questioning? He has a direction and he is really going to that direction, that worms have behaviors, have habits, and he really goes to that direction, he doesn't give them much choice, they are almost trapped into agreeing with him.
>
> Teacher 3: Right, *they have it, we are going there*.
>
> Teacher 5: Well, sometimes, teachers do that because of time, *we don't have time to go there and then there, and there, and there*, sometimes you do, sometimes you don't.
>
> Facilitator: Right. I'm sure there are many good purposes and reasons we all do this.

The facilitator starts off the above discussion by pointing out that Mr. McKnight asked a few you-questions, an indication that his questioning was focused on eliciting students' thoughts and ideas rather than the right answers. When Teacher 3 whispers "leading questions," the facilitator requests a confirmation and immediately supports her opinion. Teachers 3 and 5 then collaboratively propose that Mr. McKnight adopted a line of questioning aimed primarily at leading students toward the topic they would be investigating in their inquiries (i.e., earthworm behaviors). This analysis is supported by the Facilitator who then points out that Mr. McKnight tended to ask only "yes-or-no" type of questions (as opposed to open-ended questions). In other words, rather than eliciting students' prior knowledge, Mr. McKnight adopted a convergent line of questioning aimed primarily at getting his students to agree that earthworms indeed had habits or behaviors that could be investigated. Engaging in exploration of earthworm behavior would appear pointless had students not agreed to the notion of earthworm habits. Moreover, the Facilitator identifies Mr. McKnight's questioning as being Socratic, an approach that constraints students' responses into simply agreeing with what the teacher is saying ("the students are almost trapped into agreeing with the teacher"). Teacher 3 is able to articulate a similar view by wording the following as Mr. McKnight's hidden agenda or intention throughout the video-recorded interactions: "*they* [earthworms] *have it* [habit], *we are going there*." Finally, Teacher 5 justifies Mr. McKnight's adoption of a convergent questioning approach by arguing that it avoids digressions and saves teaching time ("we [teachers] don't have time to go there and then there, and there, and there"). As can be seen, not only are the participants able to recognize and articulate the convergent nature of Mr. McKnight's questioning but also to justify its adoption in terms of classroom time management.

Toward the end of the session, the Facilitator played another video clip showing the interactions between Mr. McKnight and two of his students while observing the behavior of an earthworm placed in a small plastic tray in front of them. Throughout the video, Mr. McKnight encourages the two students to put their observations into words by asking questions such as "*How would you describe the way it's moving right now? Does the whole body move at the same time? Does the body change at all when it moves? When does it get fat, when does it get skinny? How often does it seem to explore with which end? Which end is it exploring with right now, the darker end, or the lighter one?*" When Mr. McKnight leaves, the two students discuss for a short while and then decide to write down the following observation into their worksheet: "*The dark end is like the boss*." The discussion below took place after watching the video:

> Facilitator: Any thoughts about the questioning? What was the main purpose of his questions there? I think he was trying to accomplish something very specific.
> Teacher 11: In his questioning, he was trying to get them to realize how it moved, and if it did any head lifting, trying to get them to that.
> Facilitator: Right
> Teacher 1: The focus was mainly on how to verbalize what they were observing because they seemed like they were not really focusing.
> Teacher 6: Yeah, breaking it down a little bit more.
> Teacher 1: So helping them see that they can actually put that into words.
> Facilitator: I agree, I think that's actually the focus here, it's helping them do that, helping them verbalize what observations they can really make, that seemed to be the focus most of the time. How about his questions, were his questions too leading or not? Because his questions actually pointed to, like *look at this, look at this part of the body,* is that too leading or is that what it takes?
> Teacher 6: I think they [the students] weren't focused and they needed it.
> Teacher 2: I think they did too.
> Teacher 8: I think he was really leading, he was trying to get them to notice how a worm expands and contracts as it moves, but when he realized he couldn't actually get them to see that, then he just decided on finding each end is the head.

When the Facilitator asks what Mr. McKnight was trying to accomplish with his questions at this exploratory phase of the inquiry lesson, Teachers 11, 1 and 6 all seem to agree that he adopted a line of questioning aimed mainly at helping the two students notice and verbalize how the earthworm's body changed as it moved ("to realize how it moved, if it did any head lifting", "to verbalize what they were observing", "breaking it down a little bit more"). After agreeing with the three participants, the Facilitator then asks whether they consider Mr. McKnight's questioning approach to be excessively leading or not. In response, Teachers 6, 2, and 8 collaboratively express a positive evaluation of Mr. McKnight's questioning approach, arguing that his leading questions were not only appropriate but also necessary in order to get the two students to focus on more specific aspects of earthworm movement. As a result, participants are able to articulate a positive view of leading questions as discursive devices that they can potentially use to support elementary students with limited observational and linguistic skills while attempting to make observations of natural phenomena.

While still discussing the second video, the Facilitator asked participants to evaluate the overall effectiveness of Mr. McKnight's questioning approach based on the interactions that took place between his two students after he left:

> Facilitator: Was the teacher effective or not? Because we can actually see what happens after he leaves, right? What's your evaluation?
> Teachers: They were verbalizing.
> Facilitator: Successful then?
> Teacher 1: For what I think he was trying to do, yes, because they were verbalizing, *okay let's write this down*.

As can be seen, most participants seem to agree that, after their discussion with Mr. McKnight, the two students started to verbalize and take note of more specific aspects of the earthworm's body and movement, including which end they considered to be the earthworm's head ("*the dark end is like the boss*"). Therefore, Mr. McKnight's language-centered questioning approach was considered to be successful by the participants. Later in the discussion, participants were also able to recognize and articulate a second linguistic feature of Mr. McKnight's questioning performance on the second video clip:

Facilitator: How about feedback? Did he give any feedback at all?
Teacher 6: It was on how to question most of the time, if I remember.
Teacher 9: He said *okay*, and then he would use the information in his next question to expand on what they were saying.
Facilitator: Uptake.
Teacher 9: I don't know what that's called.
Facilitator: Yeah, it's uptake.
Teacher 1: It seemed to have gotten to them because they seem to be writing it.
Teacher 9: Because that's just feedback a little bit too, *okay I must be going in the right direction if he is using the information I just said*.

When the Facilitator asks whether Mr. McKnight provided with any type of feedback, Teacher 9 points out that he continued to incorporate referential information (e.g., "getting fat and skinny," "a lighter and a darker end") from the students' answers into his subsequent questions, a discursive practice currently described in the educational linguistics literature as "uptake" (Collins, 1996; Mertz, 1996). Furthermore, Teacher 9 is also able to convincingly argue that such practice can be considered a form of feedback. By adopting uptake, not only did Mr. McKnight acknowledge students' ideas but he also evaluated those ideas positively by encouraging students to think "*I must be going in the right direction if he is using the information I just said*." In doing so, Teacher 9 demonstrates having developed a multifunctional view of teachers' questions as serving not only to elicit information from students but also as a potential and subtle source of evaluative feedback to students.

Hedges

On the fifth day of the institute, participants were offered a morning expert instruction session on the use of hedges and vague language in classroom settings. During this session, a facilitator introduced teachers to various types of hedges currently described in the educational linguistics literature, including attribution and plausibility shields, rounders, placeholders and adaptors (Rowland, 2000). Using a PowerPoint slideshow, a facilitator provided definitions and examples of the different types of hedges, and then discussed their social functions and interactional implications extensively with participants. Examination of the contents of earlier parts of this discussion revealed that participants initially held conceptually undeveloped views of hedges. This is illustrated by the following interactions which took place at the beginning of the session:

Facilitator:	I kinda want us to be thinking about where hedging, where does the use of vague language might actually be useful in our classrooms?
Teacher 6:	Well, I'm just thinking of tentativeness. Not sure.

After introducing the concept of hedges and presenting a few illustrative examples, the facilitator immediately asks participants about the social or interactional utility of vague linguistic forms in classroom settings. Teacher 6 is the only person who volunteers to offer a response to the facilitator's question. However, her response simply associates hedging with being tentative and unsure. The lack of articulation in Teacher 6's response suggests that her view of hedges is not conceptually developed, that is, it is not based on a robust theoretical conception of hedges. Likewise, the teachers expressed relatively undeveloped views of hedges in the interactions below which also took place early in the session:

Facilitator:	An example would be *widow's peak is dominant*, still our proposition. Now we say *Kim says widow's peak is dominant.* Right? Think about why we might use this kind of shield?
Teacher 1:	Well, because you are not quite sure yourself, but you are confident that Kim knows what she is talking about.
Facilitator:	We think Kim is really smart.
Teacher 1:	Yeah, so I might suggest that someone I think is smarter thinks it is true so, we are ending the discussion [laughs].
Facilitator:	Right, we're kinda treating Kim as the expert.
Teacher 6:	Or, you're just inviting other opinions, *Kim says this, what do you think?* Instead of just saying it *that's just what we are saying it*.
Facilitator:	So, it kinda sounds like what you are saying is we are being kinda neutral in our response to whatever Kim said.

After providing an example related to genetic inheritance, the facilitator asks why teachers normally use attribution shields while interacting with students. In response, Teachers 1 and 6 raise two plausible social functions: to implicitly signal to the class who the intelligent students are and to invite opinions from other students. It must be noticed that the facilitator rewords each of the two teachers' responses, helping them articulate their views in terms of expertise status and response neutrality. By doing so, the facilitator continuously help teachers to develop more articulated and elaborated conceptualizations of the social and interactional implications of classroom hedging.

After being introduced to more robust theoretical conceptualizations, participants started to develop a view of hedges centered on classroom context. This contextualized view of hedges was first introduced by Teacher 1 during a discussion about teachers' use of adaptors in inquiry-based classroom settings:

> Teacher 1: It [the use of adaptors] certainly depends on when in your lesson you are employing this kind of thing too, because at the beginning you wanna have some doubts, some questions and getting them [the students] focused into finding answers, doing things to find out for themselves.

Instead of offering generalizations about the use of adaptors, Teacher 1 points out that classroom use of hedges is contextualized, that is, how teachers use hedges and the social or interactional functions they serve may vary depending on which particular stage of a lesson plan is being implemented. For instance, adaptors can serve a motivational or engaging function in early stages of inquiry science lessons. By strategically introducing doubt, teachers can encourage their students to inquire and look for their own answers. As the discussion unfolded, participants continued to develop this contextualized view of classroom hedging, achieving a high degree of sophistication toward the end of the session:

> Teacher 6: In a discussion, it [hedging] seems to fit. Now, if they [students] are writing their answers with hedges in them, no.
> Facilitator: Right, so if on a test you get?
> Teacher 6: *I think*, *maybe*, *What should I call it? The thingie*, then [laughs]

Teacher 1:	To allow this kind of discussion in the classroom, and then on a test have like *thing* and *stuff*
Facilitator:	So, there is a disjoint.
Teacher 1:	So, there is this disjoint and that's why I have a problem with it.
Facilitator:	Right
Teacher 4:	Well, when you're getting through the learning cycle though, once you've gone past the Explain part they need to start using the vocabulary.
Teacher 1:	I agree
Teacher 4:	Then by the time you are at [interruption]
Facilitator:	Right, in Explore, they will likely not have had that terminology to use, so thingie might be completely appropriate at that point.
Teacher 1:	Even when we are at Explain sometimes there are children who are saying *Well that stuff we did before* instead of being precise, so
Facilitator:	And that's indicating?
Teacher 1:	So, that's indicating to me that they really still are not comfortable with the content.

The more robust theoretical conceptualizations presented by the facilitator allow Teacher 6 to recognize the differential use of hedges in oral and written classroom discourses. While hedging is acceptable in students' oral contributions to classroom discussions, teachers typically discourage students from hedging in their written responses to tests or exams. Immediately, Teacher 1 reacts by expressing her disapproval of such practice which is portrayed by the facilitator as constituting a "disjoint" in classroom communication. Students are required to eliminate the vague language they commonly use to talk to their teachers and peers from their writing. Teacher 4 then takes the discussion one step further by referring to the five different phases of the learning cycle (Engage, Explore, Explain, Evaluate, and Extend), an instructional model commonly used by teachers to structure their inquiry science lessons (Bybee, 1997). Collaboratively, the three discussants construct a detailed picture of student hedging throughout inquiry science lessons with a learning cycle format. According to their picture, students are likely to hedge during the Engage and Explore phases of inquiry science lessons, but students' employment of vague language is expected to reduce in the Explain phase, when teachers usually introduce relevant scientific terminology and vocabulary to students. Persistence of vagueness in students' discourse after this point is interpreted as being indicative of student discomfort or unfamiliarity with the scientific ideas and concepts presented by the teacher.

Hedging was also a recurrent topic of discussion on the sixth day of the summer institute. During the morning session, a facilitator asked teachers about hedges and their interactional functions. Participants' responses once again suggested that they had developed theoretically sophisticated of views of hedges in classroom discourse:

> Facilitator: What are hedges for? What do they accomplish for us when we speak?
> Teacher 6: Being non-committal
> Facilitator: Yeah, it's a way of avoiding commitment, and what were you saying?
> Teacher 15: Defense mechanisms
> Facilitator: Um hmm, so defending against?
> Teacher 15: Umm, possibility of failure of your response.
> Facilitator: Um hmm, and what else? What else do hedges do for us?
> Teacher 6: It leaves it open, it's more inviting for other responses.

Prompted by the facilitator's question, Teachers 6 and 15 display their theoretically developed views by identifying avoidance of commitment, defense against response failure and encouragement of multiple opinions or ideas as potential interactional functions served by classroom hedges. As the expert instruction session progressed, hedging continued to come up in the discussion. For instance, toward the end of the morning session, the facilitator and teachers discussed how hesitation markers can serve multiple interactional functions in classroom discourse:

> Facilitator: We have to be careful about what we are expressing when we are using these hedges or hesitations markers, and what our students are expressing.
> Teacher 6: I am reading the ones that are listed there and, umm, maybe it's just that they [students] are nervous.
> Facilitator: Oh, absolutely!
> Teacher 6: It's just like, if you say *okay,* and then *okay? uh, okay?* And go on, filling space.
> Facilitator: What are, so these, and in addition to these hesitations, what are some of the other ways that we have of, of letting everybody know that we wanna keep speaking and we wanna hold on to the floor?

Teacher 4: I had a teacher in junior high who used to say *okay* in place of *umm*, I think *umm* bothered him so
Facilitator: So he picked up a new one
Teacher 4: And we would count, so it was just checking to make sure, he never said *umm*
Teacher 6: He just went from *okay* to *alright*.
Teacher 1: It's different though than hearing a speaker than it is a child speaking in a classroom, because you know that some of the *umm*'s are because they are nervous, or because they are not sure how you're gonna respond to what they say, which is very different than a speaker getting up and saying *umm, umm, umm* which drives me crazy, because I don't think that's trying to hold floor, I think it's not being prepared.

While showing a PowerPoint slide with several examples, the facilitator highlights the need for teachers to be attentive to what they and their students express when they use hesitation markers. In response, Teacher 6 raises the possibility that hesitation markers are indicative of nervousness on the part of students who use such hedges as placeholders or fillers to hold on to the discussion floor while pulling themselves together. Next, Teacher 4 provides an example from her own experiences as a student -- a teacher who continuously said "okay" as a strategy to avoid the hesitation marker "umm." This example immediately prompts Teacher 1 to point out the importance of context for the interpretation of the meaning(s) of hesitation markers in classroom discourse. According to her, children's uncertainty about the teacher's reaction to their contributions motivates their use of hesitation markers, whereas presenters and teachers' use of hesitation markers is more likely to be caused by unpreparedness. The above discussion provides evidence that the teachers developed a sophisticated view of classroom discourse that took into account the interactional multifunctionality and contextual nature of classroom hedges such as hesitation markers.

Reactive Behaviors

The topic of teachers' reactive behaviors was first addressed in the morning session of Day 2. While discussing Mrs. Neuhall's questioning performance (*Teachers' Questions* subsection), participants were able to identify her apparent lack of reactive neutrality as a potential interactional issue. In the interactions below, participants discuss Mrs. Neuhall's reactions to the responses provided by her first graders:

> Teacher 5: She [Mrs. Neuhall] affirmed, whether she realizes it or not, by saying *oh, how interesting!* Or the way she responds to them [students].
> Teacher 6: And it's kinda evaluative because when the girl gave the right answer she said *how interesting*! She didn't want to say *yeah, you are right* because that kinda blows it.
> Teacher 1: Yeah, that would blow her lesson.
> Teacher 6: So, Susie [student], whatever her name was, already knows.
> Teacher 5: She didn't say that the other persons' was interesting.

The lack of neutrality of Mrs. Neuhall's reactions is first pointed out by Teacher 5 who argues that the apparent excitement and surprise of Mrs. Neuhall's comment "oh, how interesting!" serves as an affirmative or evaluative purpose, that is, it signals to students that the answer she was looking for has just been provided. This view is reinforced by Teacher 6 who argues that Mrs. Neuhall purposively avoided providing a more explicit evaluative comment to Susie. An explicit positive evaluation from Mrs. Neuhall could have had a negative interactional impact by creating the impression that the ongoing classroom inquiry was too obvious, therefore discouraging the students from further discussing and investigating the phenomenon at hand (i.e., "blowing the lesson"). By doing so, participants demonstrate their ability to focus on and eloquently articulate the social dimension of the video-recorded classroom inquiry.

The morning session of Day 9 was entirely focused on reactive behaviors commonly used by teachers while interacting with students in classroom settings. During this particular expert instruction session, a facilitator played a short video-recording of Ali, a fourth-grade teacher in Turkey, while leading a whole-class discussion about river pollution. When Ali asks his students to identify who is responsible for the pollution of Turkish rivers, a student replies "*unconscious people*," a response that is then repeated verbatim six more times by other individual students.

Furthermore, each of the students' repetitions is also repeated verbatim by Ali. Not only does Ali allow his students to repeat the same idea several times, but also requests a final group repetition from them at the end of the video. For more information about the interactions between Ali and his students see Oliveira, Colak and Akerson (in press). The following statements were provided by the participating teachers while discussing the repetitive behavior displayed by Ali on the video:

> Teacher 9: I remember being taught in a class <u>not to do that</u> [repeat students' responses], because it discourages, you know what I mean? It's interesting because you can look at it in another way, because it discourages students from speaking up and listening to each other.
>
> Teacher 6: I don't know if you were in here the day I was talking to her, this year I had a student with hearing aids, and the only way she could hear me, I was mic-ed, and it went right to her hearing aid, so I had to get in the habit of repeating, you know, what everybody said so she would keep up with what we were doing, and I was just saying how <u>I need to stop that</u>, for that reason, so they start listening to each other instead of just me.

As underscored above, both Teachers 6 and 9 hold negative views of verbatim repetitions of students' responses. Their argument is that such practice needs to be actively avoided because it can potentially discourage peer communication and interaction among the students. Furthermore, the teaching situation described by Teacher 6 highlights that, even though constant repetition of students' responses is not desirable, it may be required in some particular instructional contexts such as when a student with hearing impairment is present in the room. In contrast, other teachers expressed more positive views of verbatim repetitions of students' responses:

> Teacher 7: I know I did it on my video, I repeated everything the kids said, I don't know if, I remember being conscious of the microphone really, but you wouldn't get that information without it, but I don't know where I got it from, I think I do it all the time, repeat what the kids say. I think part of it is that those little guys, you know, they don't, sometimes they, you know, over here on this side of the, they were sitting on floor, they can't hear what others say, part of it is because of their speech, part of it is because of how they talk, but I just

do it to say it louder and to reiterate what they were saying. I don't need for them to be looking at me, I don't know why I do it.

Teacher 6: It's kind of a reinforcement for them, they will know what they are saying is important too.

Teacher 1: I think we also do that, at least I've been doing this year with all the ESL kids, because their, I understood what they said but the kids didn't understand what they said, so I repeated it to give them a voice in the classroom, because otherwise their answer would be dismissed because of the language, not because of their content.

Teacher 7 starts off the above discussion by pointing out that an examination of video-recordings of her own teaching revealed that she tended to repeat everything that her group of kindergarteners said. Teacher 7 then argues that such practice can serve reiterative ends, a communicative function especially important for younger students who often have limited communicative competence. As the discussion unfolds, participants indentify other plausible reasons for teachers to repeat their students' utterances, including reinforcement of students' contributions as being important and "giving a voice" to students whose first language is not English.

Later in the discussion, participants also considered the interactional implications of performing other repetitive discursive moves such as repeating students' wrong answers, and writing students' oral contributions on the board rather than simply repeating them aloud:

Teacher 4: How about repeating when somebody says something wrong? For example, listing on the board, I knew when I was listing on the board we would put everybody's examples.

Facilitator: I think listing on the board is even more official than just repeating out loud, right? Because it becomes something written, almost like a document, doesn't it?

Teacher 4: Probably, if you just list the right ones, but if you list everybody's.

Facilitator 2: Sometimes, what I use is like *here is what we think* and then list it on the board so the kids don't get the idea that everything on there is right, it's just what we think, we might change our ideas.

Teacher 1: Right, that's what I do too.

Teacher 14: I've done that before, then at the conclusion of it, I said okay, this is what we think so we're gonna, you know, experiment and whatever to find out if what we are thinking can happen or can change.

Facilitator: But let me ask you this though, would you write down on the board like a misconception or not?
Teacher 1: It depends on what part of the lesson you're in.
Facilitator 2: That's right.
Teacher 4: You can in the Engage part and then get rid of it at the end.
Teacher 1: If I am in the Engage part then yes.
Facilitator 2: Then you go back and look at that list and say *what do you now think about this?*
Teacher 8: Yeah, *how did our ideas change?*
Teacher 5: Otherwise, if you don't, you are putting your stamp on the wrong answers.
Facilitator 3: I don't know, you could because you can have them go back and reflect on how their ideas were changing, what did they learn?
Facilitator 2: *Look our ideas have changed, look how much we've learned*.
Teacher 1: Exactly. And then you cross them out.
Facilitator 2: Right.
Teacher 1: Ok, now we know this isn't true anymore.
Facilitator: Right, then you put your stamp there saying this is not, right? You undo it in a way.
Teacher 1: But you do it at the end though so we have the time to engage and explore and explain it all and then *now what do you think? Well, we learned this isn't true*.

As can be seen, the above discussion focuses on how teachers should react to students who provides a "wrong" answer, an issue raised by Teacher 4. When Teacher 4 points out that she usually writes all of her students' responses on the board regardless of being right or wrong, the Facilitator proposes that teacher's repetitions of students' responses can potentially have a stronger "endorsing" interactional function depending upon the communicative channel used by the teacher. Written repetitions can make students' responses appear more official than spoken repetitions because "it becomes some written, almost like a document." In response, Teacher 4 argues that, while selective transcription can indeed function as a type of official endorsement of the "right" answers, teachers can adopt a more neutral stance by transcribing all of their students' responses. Facilitator 2 then points out that she usually adds some sort of explicit disclosure such as "here is what <u>we think</u>" to the top of the column where she writes her students' responses. It must be noticed that her suggested disclosure contains the inclusive pronominal form “we” (to foster solidarity with students) as well as the mental verbal “think” (which has a hedging function). As a result, the disclosing statement suggested by Facilitator 2 explicitly highlights that the responses written on the board are both collective and tentative (“so kids don’t get the idea that everything on there is right, it’s just what we think, we might change our ideas”). Teachers 1 and 14 then point out that they also resort to similar types of disclosures in order to mark ideas written on the board as being tentative and under experimental verification.

The second half of the above discussion is framed by the Facilitator’s question “would you write down a misconception on the board or not?” In response, participants seem to agree that transcription of a misconception can occur at earlier phases of the learning cycle (“in the Engage part”) provided that, at the end of the classroom inquiry, students revisit the misconception and recognize its incorrectness (“otherwise, if you don’t, you are putting your stamp on the wrong answers”). It must be noticed that the participants are able to collaboratively articulate a view of an inquiry-based science instruction that emphasizes delayed evaluation of students’ ideas. *A priori* evaluation is avoided through explicit disclosure of tentativeness and neutrality while constructing a written record of students’ initial ideas, and self-evaluation encouraged by having students reconsider the ideas recorded in writing at the end of the classroom inquiry (“[Teacher:] Now, what do you think? [Students:] Well, we learned this isn’t true”).

The diversity of views expressed during the discussion left some teachers unsure about whether or not they should repeat what their students said. For instance, Teacher 15 included the following reflection on the report she submitted at the end of the day:

> Teacher 15: I find that when I am responding to questions I often repeat the answers provided. I am unclear now whether that is an appropriate methodology or if that is something I need to work on stopping. I repeat so the students know that I am listening and also so the verbalization solidifies their response in my

head for later recall. If I don't repeat or write their ideas down, I tend to forget what was discussed.

After watching herself on video, Teacher 15 finds out that she in fact tends to repeat students' statements in class. Although, she seems unsure about the appropriateness of this communicative practice, she entertains some possible reasons for repeating her students' answers – listenership display to students and enhancement of her own recall ability. As a result of critically examining and justifying communicative practices that she had previously adopted while implementing the video-recorded science lesson, Teacher 15 develops an increased awareness of teacher-student interaction in the context of her own classroom.

Personal Pronouns

The seventh day of the summer institute was focused on personal pronoun use in classroom settings. During the morning expert instruction session, a facilitator played a short video-recording of a classroom inquiry wherein elementary students designed and conducted hands-on investigations with earthworms. The video showed verbal interactions between a male elementary teacher and a female student who planned to investigate whether earthworms were able to hear sounds. After challenging the student to design a method of generating noise that would be invisible to an earthworm, the teacher utters the following closing utterance: "*Yeah, think about that for awhile, see what you can come up with, and if you are still, uh, if you are not sure, come back and check in with me, and I will tell you*." The interactional implications of this particular utterance were discussed extensively by participants:

Teacher 4: We would have changed it from *if you are not sure* to *if there are any more questions* to kinda avoid making that about her [the student], but *if there are any more questions, come back and let's talk about it some more*. So, just that very last line.

Teacher 14: I think there is a problem at the end when he [the teacher] was, uh, *come back and check in with me, and I will tell you*, and I heard him say that even before you showed us the script, and that was just setting her up to like okay, *well I've got to go back and get the right answer, I will just write whatever answer I can and I will come back and he will tell me the answer*, but you know, different kids react in different ways, but when they go back and really think about it to try to get the right answer, they stress and get anxiety about it because they know there is one answer because he said *come back I will tell you*.

Teacher 11: I kind got it that he [the teacher] is saying like *if you need anything else, come back and I will help you.*

Teacher 4 suggests that the expression "if <u>you</u> are not sure" should be replaced with "if there are any more questions." Such a replacement, she argues, would have made the teacher-student interaction more focused on the investigation itself rather than on the students' competence or ability to investigate. Teacher 4 also suggests that instead of saying "if <u>you</u> are not sure, come back and check in with <u>me</u>, and <u>I</u> will tell <u>you</u>," the video-recorded teacher should have said something like "if there are any more questions, come back and <u>let's</u> talk about it some more." As underlined above, Teacher 4 seems to suggest, though in an indirect manner, that the teacher should have avoided the second person pronoun "you" and strategically replaced the "I/you" contrastive pair with the plural pronominal form "we." The former would have placed student agency in the background, whereas the latter would have fostered solidarity (social proximity or oneness) rather than authority (social distance or separation). The apparent lack of explicitness and articulation in Teacher 4's suggestions indicates that her interactional views of personal pronouns are still relatively undeveloped.

Similarly, Teacher 14 argues that the statement "come back and check in with me, and <u>I</u> will <u>tell</u> <u>you</u>" can have a potentially negative social impact on the teacher-student interactions by encouraging the student to focus on finding the "right" answer which is known by the teacher. Such an interpretation seems to be based on the fact that the teacher uses the communicative verb "tell" which in classroom contexts is frequently associated with the object "answers." In contrast, Teacher 11 proposes a more positive interpretation of the verb "tell" as meaning a willingness to help on the part of the teacher. Neither Teacher 14 nor Teacher 11 articulate explicitly how the pronouns "I" and "you" serves to separate the teacher (the individual who knows the right answer and who is willing to help) from the student (the individual who needs to find out the right answer and who needs help), thus suggesting that both teachers hold relatively undeveloped views of personal pronouns.

Throughout the day, participants continued to develop their views of personal pronouns by reflecting upon and articulating interactional aspects of their own teaching practices and classroom contexts. For instance, Teacher 4 described how she was able to make strategic use of personal pronouns while implementing classroom inquiries by having her students work in small groups:

> Teacher 4: I use a program that encourages, uh, you put the kids in groups, so the inquiry that students do in my class is always done in a group, unless we do it as a whole class, and the solidarity that they are building, I want that group to be successful by themselves while I am doing whatever else I need to do in the room, so the *you*, I kept waiting for him [the teacher on the video] to say *your group, what does your group think about this?* Because, it's very difficult, you know, to have each child doing their own inquiry question, and having a group gets me out of being in the in-charge mode, but helps them develop which I think is a greater life skill, being able to work in groups by themselves. And, then you may work in one group more than the others and then it's *we* and *let's*, but there is a stepping stone between *we're all doing this in the classroom* and *you are on your own*, which is helping them connect to each other in small groups.

Teacher 4 points out that her collaborative approach to classroom inquiry fosters in-group solidarity among the students, allowing her to relinquish control over their learning experiences. More importantly, such collaborative approach enables Teacher 14 to strategically shape her use of personal pronouns while interacting with students by substituting the singular pronoun "you" (the individual student) for the plural form "you" (the group of students). Such a replacement serves to promote collective student agency and accountability in the more independent groups. In contrast, Teacher 4 employs solidarity-building pronominal forms such as “we” and “let’s” while working with groups that require more guidance from her. Such a differential use of personal pronouns, Teacher 4 argues, allows her to create a supportive interactional atmosphere wherein her students do not feel as though they were inquiring by themselves, even when she uses socially distant or detached pronouns such as “you” or while she is helping other groups.

Later in the discussion, the teachers were able to articulate the potential implications of particular personal pronouns for classroom management. For instance, some teachers highlighted the benefits while others emphasized the potential risks of employing the solidarity-building pronoun “we” while interacting with elementary students:

> Teacher 8: I think it’s so true that in the younger grades you have to teach and say *we* because, because you have to let all your kids know that we’re gonna be working today so that, because the kids will want to roll on the floor, *we are working*, I mean, first graders, that’s what they will do unless you really have <u>a cohesive group</u>.
>
> Teacher 14: I was in a much different setting with eight kids in my class and, so I could use *we* all the time, because I was like, I mean, it was such a small group basically, so *we were gonna do this, we were gonna do that*, and no matter what age they were, I had seven of them in everyday in math, *today in everyday in math, we are going to this, we are going to do that*, and for science *okay, today in science we are going to do this*, umm, *what do you think if we did this?* Or *would you like if we all did this,* and I used *we* all the time, and actually I thought it was, it was not good that I was doing that because I, I felt like, people would perceive as me <u>not being authoritative in the sense of not having enough control</u>, because I was like that with my students like *let’s do this* or *we’re gonna do this*.

As underscored above, Teachers 8 and 14 express contrasting views with regard to the effectiveness of using the pronoun “we” as a verbal strategy to manage elementary classrooms. Teacher 8 argues that the pronoun “we” can be effectively used by elementary teachers to foster group cohesiveness or solidarity, thus making student behavior more manageable. In contrast, Teacher 14 draws on her previous teaching experiences in order to point out that teachers who frequently employ the personal pronoun "we" can be potentially perceived as lacking authority and as being unable to control student behavior, thus leading to classroom management difficulties.

The issue of teacher authority and classroom management continued to be discussed throughout the second half of the morning session. For instance, when a facilitator asked whether being authoritative was inconsistent with inquiry-based science teaching, Teacher 3 replied:

> Teacher 3: It's like somebody will say *this is an unstructured lesson*, okay? That's an example. That's not a good term, there is structure, you can have kids doing inquiry all over, but there is a place for that authority and there is a place for that structure, it may not seem that everybody is sitting down on their seats and doing exactly the same thing, but in inquiry and in anything where there is structure, <u>there has to be authority, there has to be. People need it.</u> And I will argue that one until I retire from teaching.

Teacher 3 argues against a view of classroom inquiry as lacking what she calls a "structure," a term that she seems to use in reference to the interactional or social organization of classroom settings. Moreover, teacher authority is seen as an inherent part of classroom structure, therefore denying teachers' authority during classroom inquiries would be equivalent to denying the existence of a classroom structure. Rather than simply discussing whether it is more appropriate for teachers to use the solidarity-building "we" or the authoritative "I" during inquiry, the facilitator's question encourages the teachers to articulate the interactional dimension of classroom inquiry, providing Teacher 3 with an opportunity to make a strong and eloquent argument against the denial of teachers' authoritative interactional role. As the discussion unfolded, participants started to question and to elaborate on the meaning of the word "authority":

Facilitator: Where do you think authority would fit best in the learning cycle?
Teacher 6: What kind of authority are you talking about?
Facilitator: That's a good question.
Teacher 6: An authority on the subject? Or an authority on managing time, materials, and student interactions?
Teacher 1: There will always be authority on the management of time and materials.
Teacher 3: Yeah, in managing, I think we [teachers] can be authority as in managing.

As can be seen above, Teacher 6 proposes that a distinction must be made between subject authority (i.e., the person who is an expert on science) and management authority (i.e., the person in charge of keeping track of time, organizing materials and supervising students). Teacher 1 then adds that the latter is an integral part of classroom inquiry regardless of what phase of learning cycle is being implemented, a view that is also held by Teacher 3. Toward the end of the discussion, participants seemed to have developed an increased awareness of teacher authority, being able to distinguish among its different nuances:

Teacher 1: Authoritarian or authority? Those are two different things.
Facilitator: Can you elaborate maybe?
Teacher 1: Well, I mean, authoritarian would be *you do it my way, and you do this, you do that, you do that,* you know, it's not going to be much inquiry or exploration because I've got a goal and I want you to get to it, and it's my way or the highway, you know, that's authoritarian, that's different than being an authority or authoritative.

Teacher 1's argument is that adoption of an authoritarian teaching role is different from being an authoritative teacher. While the latter is viewed as an inherent and necessary part of teacher management of classroom inquiries, adoption of an authoritarian teaching role (i.e., constantly telling students how to conduct their investigative explorations) is considered to have the potential to actually prevent students from engaging in scientific inquiry. The authoritarian teacher is excessively focused on achieving particular instructional goals, not providing students with the freedom or flexibility they need to inquire and to learn more independently.

After Day 7, participants continued to demonstrate having developed an increased sensitivity to personal pronoun use and teacher authority in classroom discourse. For instance, during the morning expert instruction of the ninth day, a facilitator provided participants with a short transcript of an inquiry-based lesson in which a professor interacted with a group of three undergraduate students who were trying to explain how wax candles worked. For the complete transcripts and a detailed discourse analysis see Oliveira et al (2007a). While discussing the transcribed interactions, participants focused on how the professor employed personal pronouns:

> Teacher 14: Umm, I think it's interesting too, it seems to me that they [the students] are writing answers to questions because Amy says *we are on eight* which means the question number eight, and then when the professor speaks, he says *you haven't told ME why there is a flame sitting on the top of the candle*. So, it looks like he is maybe looking at their answers to their questions, and then he says *I don't think you've explained it, you just said it was made out of wax*. So [interruption]
>
> Teacher 1: It sounds like we are missing something.
>
> Teacher 14: Yeah, but it is like *these answers that you are writing down are for my, for me, you're writing them for me*. I know he is like the audience who is going to be reading them obviously, probably grading them on what they are writing down but a lot of times, I guess, maybe, teachers of younger grades have students write things down for themselves, you know, in a journal, recording information, recording observations, recording inferences, those kinds of things, I guess we do more of that, it seems like just in this particular setting [interrupted]
>
> Facilitator: Right, so, maybe this was a lost opportunity to play around with the pronouns a little bit.
>
> Teacher 14: He wants the students to be in charge of their learning but he is like *you are doing this for me*, or whatever, *you are answering these questions for me*, so their goal seems to be a little bit like *okay, so we've got to say it the right way, how would he say it? How would he want us to say it?* Instead of like *okay, what's going on here? How can we figure this out?*
>
> Facilitator: And I assume that the danger of this is that at the end of the process, instead of the reward being the *ah hah* moment when you figure it out, the reward would be this sort of pleased expression on the teachers' face.
>
> Teacher 14: Yeah, *I said exactly what he wanted me to say*.

In her first contribution to the discussion, Teacher 14 describes what she considers to be the instructional context of the verbal interactions presented by the facilitator: a professor reading and commenting on the written responses that a group of students provided to a series of questions. She then points out that, by prefacing his assessment with the expression “you haven’t told ME,” the professor explicitly positions himself as the sole audience who will be reading the students’ writing assignment as well as the authority who will be grading their work. Such interactional positioning, she suggests, is less often adopted by elementary teachers who tend to favor self-writing, that is, assignments in which the students are asked to position themselves as the audience for their own writings (e.g., diaries and journals). More importantly, Teacher 14 eloquently argues that the professor’s explicit interactional positioning as the “audience” or “grader” can potentially have a negative impact on students’ inquiry by encouraging them to focus on pleasing the professor (i.e., reporting what the professor wants to read) rather than on learning about the scientific phenomenon under investigation. Teacher 14’s comments and arguments provide evidence of her increased level of awareness of personal pronoun use and its interactional implications for inquiry-based science instruction. Like other participants, Teacher 14’s views of personal pronouns developed substantially as a result of participating in the summer institute.

Directives

The morning session of the eighth day of the summer institute was devoted to teachers’ employment of directives in classroom settings. Using a PowerPoint slideshow, a facilitator described and illustrated a variety of directive statements commonly used by teachers, including imperatives, interrogatives and declaratives. The facilitator also presented the findings of research on linguistic strategies that teachers use to construct politeness while giving directives to students, including indirect strategies aimed at gaining hearer’s cooperation (e.g., “What a nice group of kindergartners! It makes me so happy to see all your smiling faces!”), praising students who are displaying a desired behavior (e.g., “Oh I like the way Tammy and Barbara are sitting down!”) and negative politeness, that is, disguising their directives as suggestions by appearing to be giving students an option (e.g., “Joey would you turn around so I can see your face?”).

In the first half of the morning session, teachers discussed the appropriateness and effectiveness of employing polite language to direct students. For instance, in the following excerpt, participants describe and discuss classroom situations in which using the politeness marker *please* while addressing a student would be considered appropriate as well as situations wherein use of *please* would be inappropriate:

> Teacher 6: I think, other teachers and I were having this discussion when, you know, we were watching the videotape, this is a conversation that we have with student teachers all the time and, I mean, I know it’s not polite but I think it’s hard, you know, sometimes you just gotta get to the point, and it’s like when I say *sit*, I don’t usually say *please*, because to me please implies a choice, like, “*would you please shut the closet door?*” would be okay, you know, I don’t care, but if I need you to sit down it’s like you need to have a seat.
> Teacher 1: I think that’s fine, because I always say that [imperatives].
> Teacher 6: It’s a teacher voice.
> Teacher 2: There is a difference between a request and a command. Like a request is having them close a closet door which is a little bit different, now *please* is okay there because if they don’t do it is not the end of the world. But if they are not sitting, that’s more of a problem, you know.

After pointing out that she does not always say *please* when she addresses her students, Teacher 6 argues that there are teaching situations in which objectivity (“getting to the point”) must take priority over politeness. For instance, effective management of student transgressions of behavioral norms (e.g., “not sitting down”) demands the employment of objective linguistic forms such as imperatives. In contrast, polite formulas such as *please* and interrogative statements are appropriate for dealing with ordinary classroom situations that do not involve student misbehavior (e.g., “shutting the closet door”). Teacher 6’s main argument seems to be that teachers must necessarily employ what linguists consider objective and impolite language in order to develop a "voice" that will enable them to manage their classrooms. Such a view is supported by Teachers 1 and 2 who argue that the examples provided by Teacher 6 are illustrative of classroom situations that require teachers to give commands and requests, respectively.

As the discussion continued, other teachers started to share their practices and views of polite language, addressing other issues related to the employment and potential implications of linguistic politeness for classroom management:

> Teacher 7: I know that in kindergarten I use the word *please* a lot. Even if it's like *please stop doing that*, and then the second time is like, uh, *now*, I mean, then it's like I watch my back.
> Facilitator: And it is a way of modeling how you want them to treat other kids too.
> Teacher 7: Yeah, I ask them, and then if they do, I will tell them like *thank you* in return.
> Teacher 1: I do that too.
> Teacher 6: Yeah, I think it's more important to recognize the good stuff they are doing with all that nicety stuff, but, I mean, by first grade they know the deal about school, if I am telling them to sit down, it's probably a conversation they had before. It's not a request. I think it just kinda bridges the gap between this is a suggestion, or *I mean it*.

In her first contribution to the discussion, Teacher 7 describes how she tends to use the politeness marker *please* to deal with kindergarteners' initial behavioral transgressions. However, recurring student misbehavior is handled with language that is increasingly more objective and less polite. Furthermore both Teachers 7 and 1 suggest that they frequently use polite linguistic forms such as *please* and *thank you* as a strategy aimed at socializing students into what is considered to be polite ways of interacting with peers. Finally, Teacher 6 argues in favor of the use of polite language ("nicety stuff") to highlight what is considered to be good or acceptable student behavior. However, she continues to advocate the use of less polite formulas when handling student mischief, a practice that she justifies in terms of making emphatically clear to students who are aware of school behavioral norms that they are receiving a command rather than a suggestion to discontinue their misconduct.

In the second half of the morning session, the facilitator showed participants a video-recording of herself while implementing a classroom inquiry on electricity with a group of primary students. The following interactions took place immediately after watching the videotape:

> Facilitator: Did you see a lot of directives? Yeah, I was telling them all kinds of stuff to do, *do this*
>
> Teacher 6: I don't know how else you are gonna do it, I mean <u>you are the teacher</u>, you've gotta give directions otherwise they are all gonna be rolling on the floor and putting their hands in their pants [laughs].

Teacher 6 argues that "giving directions" is a defining and necessary characteristic of being an elementary teacher, also providing two examples of what she considers to be unacceptable student behavior (i.e., "rolling on the floor" and "putting their hands in their pants") in order to illustrate the type of student misconduct that teacher directives are supposed to repress. In other words, Teacher 6 considers giving directions to be a discursive practice aimed primarily at inhibiting elementary student misbehavior rather than a means of modeling polite verbal behavior to students.

While discussing the video, several participants described and illustrated directing strategies used by them to deal with student misbehavior in their own classrooms. The directive strategies described by participants suggest a tendency to avoid dealing with or addressing student misconduct directly:

> Teacher 6: Sometimes it doesn't come from me, it's just, it's just more anonymous, like when we are in line trying to go somewhere and they are, you know, just crazy, there is no way we are leaving the room, I will just say, you know, *raise your hand if you are next to somebody that is talking*, you still get students that are clueless, and then I usually like, umm, *touch your ear if you can hear me, touch your nose if you are listening*, and then if it gets to the

> third point it's like *do the quiet sign if somebody next to you is talking*, and that does not mean SGHH, because I hate SGHH, and then I went, I mean, where it's just so blatant, it's *raise your hand if you are next to somebody that is talking*, and here is Cole surrounded [laughs].

Rather than commanding students who are talking to listen, Teacher 6 gives students who are listening commands to physically display their listenership (e.g., raising hands, touching ears, doing the "quiet sign" with an index finger in front of the mouth). By doing so, Teacher 6 avoids addressing mischief makers directly, instead directing compliant students to demonstrate their exemplary behavior to others. Teacher 6's strategy is to highlight the transgressing students' inability to listen by creating a social context in which they will appear to be incompetent listeners, or in her words "clueless." From a linguistic perspective, it can be argued that Teacher 6 is actually being impolite with well-behaved students by using imperatives to address them. At the same time she is polite with students who behave badly by addressing them in a more indirect manner. This practice seems to be the exact opposite of her previously expressed view of polite language ("nicety stuff") as being appropriate for highlighting appropriate student behavior ("the good stuff they are doing") rather than misconduct.

The directive strategies adopted by other teachers also suggested a similar tendency to avoid calling attention to students' bad behavior:

> Teacher 4: I think the way you can tell an experienced teacher from an inexperienced teacher is when you stop reacting to all that [student misbehavior]. In fourth grade, it's a point where they are in charge of their intention, *if you wanna dink around the whole time, that's fine, but do not, do not go disturb somebody near you*, that's where the line needs to be drawn, *stop it now*, because they are keeping somebody else from paying attention.
>
> Teacher 7: I have a great class, but, I just do positive reinforcement, I find that if you say *I like how Lee is sitting*, and before you know it you have five, you know, those kids all doing it and don't have to say *stop doing that, stop doing that, stop doing that*, and while you are doing that you start loosing other kids. I just kind of changed my mentality and it helps.
>
> Teacher 1: Also, if you say *stop, stop, stop,* they are the ones getting the attention, the good kids are not getting any attention.

Teacher 11: Sometimes, like, it's easier to see those people doing the bad things, it's harder to see anything else but those bad things.

Teacher 4 starts off the above discussion by pointing out that she tends to ignore students' mischief, a strategy that she considers to be indicative of teaching experience. Instead of continuously interrupting her teaching to explicitly address every single act of student misconduct, Teacher 6 only handles disruptions that can potentially distract and prevent other students for learning. In other words, Teacher 6 allows her fourth graders to behave in ways that are not conducive to learning (e.g., not listening or paying attention to what the teacher is saying) as long as they are not disruptive. However, as illustrated by her emphatic performance of the type of directive behavior she employs in her classroom, disruptive student behavior is explicitly dealt with objective and direct language such as imperatives ("*if you wanna dink around the whole time, that's fine, but do not, do not go disturb somebody near you… stop it now*").

As can be seen above, Teacher 7 also prefers to highlight the type of student behavior that she considers to be desirable (e.g., sitting quietly) rather than to call attention directly to students who misbehave themselves, a directive strategy that she calls "positive reinforcement." Teacher 7 seems to view explicit reinforcement of "positive" or good student behavior as being less distractive then explicit criticism of negative or bad student conduct. Similarly, Teachers 1 and 11 recommend avoidance of direct criticism of student misconduct, arguing that such practice gives too much attention and visibility to "the bad students." By highlighting the surrounding good behavior, these teachers create an interactional context wherein student misconduct is kept at the background rather in the foreground or center of classroom discourse.

As the session progressed, teachers' views of directives seemed to become increasingly developed and refined. For instance, some teachers demonstrated having developed a high degree of sensitivity to the social or interactional implications of the specific types of directives that elementary teachers in different grade levels employed while addressing their students:

> Teacher 4: When the kids are little they care more about what the teacher thinks, so they try to please. When they get to fourth grade, well maybe third grade even, umm, they are starting the transition over to caring more about what their peers think, so the *you need to*, to me, is more of a group, *your group needs to do that*, because that's a peer thing. If I stand up there and say *I want you to do this*, they are to the point of like *whatever* [laughs], you know, *I am not here for you*, that's the social development away from adult-centeredness, self-centeredness to peer, that's my opinion.

As can be seen above, Teacher 4 is able to articulate a view of elementary teachers' directive behavior that is centered on elementary students' relative levels of social development. Her argument is that elementary teachers at different grade levels tend to use different types of directives depending upon the level of social development of their students. Primary teachers tend to identify themselves explicitly as "directors" or "commanders" and to word their directives as personal requests (e.g., "I want you to sit down") because primary students are in a stage of social development that is adult-centered, therefore pleasing the teacher is important to the students. In contrast, third- and fourth-grade teachers tend to remove themselves from their directives and to employ statements of necessity (e.g., "you need to sit down") because most of their students have transitioned into a peer-centered stage of social development, thus what the teacher wants is no longer a priority to students.

Teachers' views of politeness also seemed more developed toward the end of the morning session. For instance, some teachers demonstrated having developed an increased awareness of the importance of considering the tone or intonation of teachers' directives:

> Teacher 3: It's not what you're saying, it's how you say it, okay? If you're being polite in what you say, it's how you are saying it.
>
> Teacher 6: I think the same thing, the tone, you can be direct and give direction without all, you know, all the extra words, it's the tone, you know, that you're not

> talking to them like they are dogs, you know, *sit* [emphatic tone], you know, you can also say *sit* and it just sounds like a suggestion.

As highlighted above, Teacher 3 introduces the idea that manner of speaking ("how you say it") is more important than content ("what you say") when considering the relative (im)politeness of teachers' directives. Next, Teacher 6 expresses her agreement, arguing that teachers' politeness does in fact depend on "the tone" of their directives. In her illustrative performance, Teacher 6 shows that even an imperative statement such as "sit" can be made sound like a "polite suggestion" when uttered with the proper intonation, thus demonstrating that it is possible for teachers to give directions that are simultaneously direct and polite. In other words, teachers do not necessarily have to speak in an indirect manner in order to be able to give polite directives to students.

Poetic Language

On the ninth day of the SMIT'N institute, teachers received expert instruction on the nature and social functions of poetic speech. Using a PowerPoint slideshow, a facilitator defined and provided several examples of commonly used poetic linguistic forms, including sound repetitions such as alliterations (e.g., "Suzy sells sea shells"), rhyming (e.g., "the cat in the hat") and reduplications (e.g., "piggly-wiggly"); word repetitions such as couplets and triplets (e.g., "the good the bad and the ugly"), tautologies (e.g., "boys will be boys") and chiasmus (e.g., "ask not what you can do for your country, but what your country can do for you"); and poetic speech figures such as metaphors (e.g., "war is hell"), similes (e.g., "life is like a box of chocolates"), exaggerations (e.g., "I've told you a million times"), understatements, metonymies (e.g., "a tasty dish") and synecdoches (e.g., "lend me a hand"). During the morning session, the facilitator also emphasized that speakers commonly resort to poetic language in order to foster audience involvement and to increase listeners' ability to recall the contents of their utterances. For this reason, poetic language constitutes a crucial aspect of classroom discourse.

Initially, the teachers seemed to have some difficulty with the notion of involvement, a theoretical concept commonly used in the field of linguistics but not in education. Instead of involvement, science educators tend to utilize concepts such as student engagement and excitement. The utterance below illustrates how some teachers seemed to struggle with the linguistic notion of involvement:

> Teacher 14: I think that overall, like using language that, umm, sticks with them [students], you said it builds involvement, but it also builds, umm, excitement, and I always to try to make my science exciting for the students because I feel like, umm, specially with my students in particular, they have a hard time remembering things like that, and short term, long term memories, those kind of things. So making it exciting, they say *remember that time when you did that?* You know? So, with the language making it more exciting by giving them some way to remember things, they all remembered the time when one of the teachers did the water cycle dance or water cycle song, and everything, and they learned the water cycle song, and they all remembered that because it was like exciting and it was the language thing, we weren't actually going through water cycle, but they were, you know, doing that language thing, umm, songs, rhymes, poems and things like that helped them remember some of those, it was almost a mnemonic clue to remember maybe a process, or something about, something that they learned, so it makes it exciting and then they wanna be involved and remember.

Drawing on her previous teaching experiences, Teacher 14 provides an example of a particular event that took place in her own classroom wherein she observed that poetic language indeed enhanced her students' ability to recall information presented during a science lesson on the water cycle. This example is offered as evidence to validate the facilitator's theoretical perspective on poetic linguistic forms as being discursive devices that speakers use strategically to stimulate hearers' recall of uttered information. Furthermore, Teacher 14 expresses a view of poetic language (referred to as "the language thing") as a means for fostering student excitement in addition to creating linguistic involvement. However, her statement does not clarify exactly what she considers to be the difference between the concepts of excitement and involvement.

As the day progressed, participants' views of poetic language appeared to develop considerably. For instance, there was evidence that some teachers developed an increased awareness of classroom poetic language in the PowerPoint slideshows they created for their presentations. Teacher 1 created a slide in which she listed several questions related to the use of poetic language in science classrooms (Figure 4.3). In her questions, Teacher 1 raised issues such as the potential inability of elementary students (both non- and native English speakers) to comprehend idiomatic expressions used by teachers, and differences in use of poetic language among males, females, teachers and students. Teacher 1's ability to raise such complex instructional issues suggests that, by the end of the institute, she had developed a relatively high degree of sensitivity to teachers and students' use of poetic language in science classrooms.

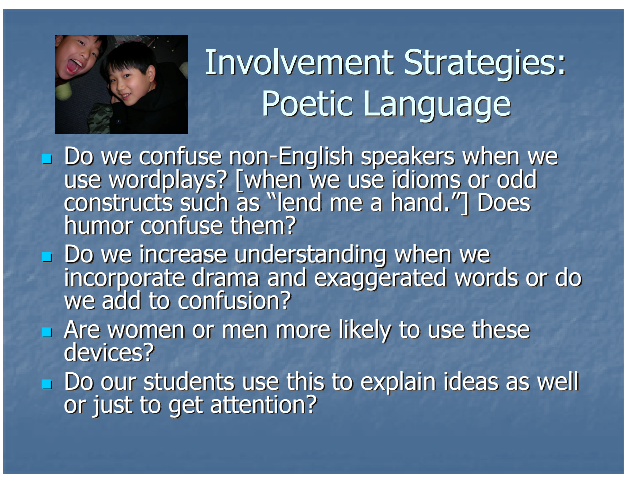

Figure 4.3 – PowerPoint slide on poetic language created by Teacher 1.

Examination of teachers' reflective reports revealed that participation in the expert instruction, group discussions, and collaborative assessments encouraged the teachers to develop of a variety of views on the use of poetic language to teach science at the elementary grade levels:

Teacher 15: I feel this type of language [poetic] used in classroom discourse is crucial to the atmosphere and resultant relationships established between student and teacher.

Teachers 10 and 13: The advantage of using poetic language is that it keeps your lesson from being dull and uninteresting. Poetic language also encourages the listener to think about the meanings of words and the purposes they serve.

Teachers 7, 11 and 12: We feel that a teacher must be extremely careful of word choice and not use a lot of metonymy, which are often taken too literally by primary aged students. Poetic talk does not really belong in a kindergarten classroom.

The first two quotations were provided by elementary teachers who held more positive views of elementary teachers who used poetic language in science classrooms. In their responses, these teachers emphasized beneficial effects such as creating a positive social climate in the classroom, maintaining student interest, and enhancing student understanding of particular words. In sharp contrast, Teachers 7, 11 and 12 expressed concerns and more negative views of poetic language, depicting it as a verbal practice that can be potentially confusing and unintelligible to elementary students in the lower grade levels.

Teachers' Final Interactional Views

On the last day of the SMIT'N summer institute, after participating in all professional development activities, the same group of fifteen elementary school teachers was again asked to describe how they conceived of the teacher-student interactional dimension of inquiry-based science instruction (Appendix B). Provided below is a descriptive account of the teachers' final interactional views as reported in their written responses to the second survey/interview.

In the first question, teachers were asked whether they continued to view their interactions with students in the same or in a different manner after having participated in the SMIT'N institute. In response, ten teachers reported that the institute encouraged them to look at inquiry-based teacher-student interaction with different eyes:

Teacher 10: I think I will be more careful with my questioning and response wording. I didn't realize the impact your wording can have.

Teacher 13: I will pay closer attention to the types of questions, responses, and pronouns that I use.

Teacher 15: Now I realize the importance of the choice of each word I use in my discourse and how the words can subtly affect student learning.

Teacher 8: From now on I will be more aware of the role language plays in the classroom.

Teacher 5: I became more aware of what I do. How I interact with students and perhaps why.

The above responses highlight that the participating teachers developed a new conception of inquiry science teaching centered on classroom discourse and teacher-student interaction. Teachers who once tended to overlook their interactions with students now demonstrate an increased awareness of the interactional and educational implications of the language they use to address students during inquiry-based science activities. Rather than being limited to general and nonverbal teaching practices, teachers now provide responses emphasizing the potential impact that specific speech behaviors such as questioning, response wording and pronoun use can have on inquiry science teaching and student learning.

Unlike in the first day of the institute (when most teachers tended to identify general, non-interactional teaching strategies), post institute teachers were able to focus specifically on the teacher-student interactional dimension of inquiry-based science teaching. When asked about the social roles and classroom relationships established with students during inquiry (question 2), not a single teacher provided general descriptions of non-verbal teaching strategies. Instead, several teachers (7 out of 15) offered responses that emphasized the adoption of facilitating or guiding interactional roles:

Teacher 5: I see myself as a facilitator and my students as the scientists. I hope I facilitate their excitement, discovery, and learning of science through inquiry.

Teacher 13: I see myself as the guide – the one who asks questions and gets the lesson started. I let my students do the investigating and try to make sure they are on track and working.

Like other SMIT'N participants, the above teachers portray inquiry-based science teaching as an instructional approach in which students are placed in the center or foreground of the learning process by being allowed and encouraged to act as scientists or investigators who learn independently while pursing scientific discoveries. At the same time, the teachers place themselves in the background of the science learning process as guides or facilitators who ask questions and supervise students' ongoing scientific inquiries.

Two teachers described their relationships with students engaged in scientific inquiry as being open. These teachers sought to accept all of their students' responses as a strategy to encourage further participation in classroom discussions. In contrast, nine other teachers preferred to describe their inquiry-based science teaching practices in terms of the establishment of more symmetric forms of teacher-student relationship:

Teacher 3: I am the facilitator, helping, guiding, and inquiring with them [students].

Teacher 11: Students guide and are in some control of what they discover. I shouldn't tell them if they're right or wrong, and I will discover with them.

Teacher 15: We are in it [inquiry] together. I found that approaching the discovery as something each of us is vested in then the results will be more grand and ultimately more meaningful.

As underlined in the above quotations, many teachers often viewed themselves as being partners who inquired along with their students. These teachers envisioned themselves discovering answers side by side with their students rather than adopting a more prescriptive and detached orientation toward students' answers (i.e., being concerned about whether the students found out what scientists considered to be the right answers). Put differently, after the institute, many teachers began to perceive inquiry-based science teaching and learning as a joint endeavor wherein they shared a more or less equal social status with their students, establishing a type of classroom relationship in which nobody laid claim to knowing the right answers.

In the second survey/interview-guide, teachers were once again asked to identify which interactional abilities they considered to be the most important for inquiry-based science teaching at the elementary school level (question 6). Among the most commonly mentioned communicative abilities were responding skills (identified by 6 teachers as being important), questioning skills (identified by 5 teachers), employment of personal pronouns (identified by 1 teacher), and use of politeness while giving directives (identified by 1 teacher).

The above findings suggest that the summer institute served to increase participating teachers' awareness of responding as an essential communicative skill when it comes to teaching science through inquiry. Unlike in the first day, when not a single teacher identified an ability to respond to students as being important, several teachers recognized its importance in the last day of the institute:

> Teacher 5: The way a teacher questions and responds are equally important. You can't have one without the other in a classroom

> Teacher 9: Responding – students are very sensitive to the feedback from their teacher.

> Teacher 12: Responding because people need to realize that responding comes in all forms i.e. voice, eyes, face, hands, body language, etc.

> Teacher 15: The whole concept of IRE vs. IRF and how setting the stage for evaluation of all responses causes the students to think for the right answer and not just think which leaves minds open to unexpected answers.

As illustrated by Teacher 5's response, participation in the SMIT'N summer institute encouraged elementary teachers to view responding and questioning as complementary and equally important skills to inquiry-based science instruction. Furthermore, Teacher 12 demonstrates an increased awareness of all the different manners (both verbal and nonverbal) by which instructors can respond to students while engaged inquiry. Lastly, Teachers 9 and 15 highlight that it is very important for instructors who set out to teach science through inquiry to provide their students with feedback (as opposed to evaluations) and to emphasize independent thinking rather than having students search for what is considered to be the right answers.

Five teachers continued to emphasize the importance of having good questioning skills in order to be able to effectively teach science though inquiry:

> Teacher 6: <u>Authoritarian vs. constructivist questioning</u> techniques. Authoritarian conveys the idea that the teacher is a source of knowledge, constructivist conveys the idea that the student can build knowledge more independently.

> Teacher 11: <u>Questioning</u> – it opens their [the students'] minds.

The above quotations provide evidence that the SMIT'N institute also served to develop elementary teachers' awareness of their questioning practices. More than simply recognizing the importance of asking good questions, Teacher 6 as well as others became more aware of the social implications of the act of asking questions to students. Far from being a neutral discursive move, posing questions to students can serve to either establish the teacher as an authority (authoritative questioning) or encourage students to construct their scientific knowledge more independently (constructivist questioning).

The last two elementary teachers included socio-emotional abilities in their selections of the most important communicative skills for effective inquiry-based science instruction:

> Teacher 10: I think use of <u>personal pronouns</u> is the most important because I want my <u>students to feel like I'm in it with them</u>.

> Teacher 13: Questioning, responding and <u>politeness and directives</u>. As a kindergarten teacher, it's important to use good interaction from the start. I want my

students to feel comfortable with me and comfortable enough to ask and answer questions.

As indicated, both of the above teachers selected communicative abilities related mainly to social and emotional aspects of inquiry-based science teaching. Teacher 10 identifies effective use of personal pronoun as an important verbal means for creating an atmosphere of inclusiveness and support during scientific inquiries. In contrast, Teacher 13 identifies the ability to be polite while giving directions to students as an important way of fostering a classroom climate of trust and comfort wherein students can feel free to ask and answer questions.

In question 4, teachers were asked to identify what they considered to be their interactional strengths or abilities when it comes to teaching science through inquiry. Unlike the first day of the institute, when many participants overlooked teacher-student interactional aspects of inquiry, teachers this time provided answers focused specifically on communicative abilities they used to interact with students engaged in scientific inquiry:

> Teacher 5: I think I'm good at directives and politeness. I'm definitely a *we* type of teacher.

> Teacher 6: I am more poetic in involvement and engagement than I realized.

> Teacher 10: I think my use of 2nd person pronouns is my strength. I use lots of *we* and *let's*.

> Teacher 15: I am strong with politeness within directives as well as my use of poetic methods of speech.

The above quotations illustrate several of teachers' most commonly self-identified interactional strengths such as being polite while giving directives to students (mentioned by 4 teachers), ability to use the second person pronoun "we" to foster inclusiveness in the classroom (4 teachers), ability to use poetic language to foster student involvement or engagement in their inquiries (3 teachers), and questioning skills (3 teachers). These results suggest that the SMIT'N institute promoted a change in what teachers considered to be their interactional strengths. While most teachers (12 out of 15) claimed to have cognitive skills in the first day of the institute, most of them (9 out 15) identified socio-emotional strengths such as the ability to use language to promote inclusiveness and involvement in the last day. In other words, the SMIT'N institute encouraged participating teachers to become more aware of their own socio-emotional interactional skills.

With regard to self-identified interactional inabilities or weaknesses, there were no clear patterns. For the most part, each teacher identified distinct interactional inabilities, including questioning, responding, engaging, using more IRF chains, allowing students to work independently, hedging, and using personal pronouns. Each of these inabilities was mentioned by either one or two teachers. This apparent lack of pattern is in sharp contrast to the first day of the SMIT'N institute, when many teachers tended to identify cognitive inabilities such as questioning and responding. Such results suggest that, by making teachers aware of a wide variety of communicative skills, the SMIT'N institute encouraged each teacher to recognize their own unique interactional shortcomings.

When asked to name interactional skills that they did not know about prior to participating in the SMIT'N institute (question 3), teachers' most frequent replies were hedging (identified by 3 teachers), discourse structures such as IRE and IRF (also identified by 3 teachers), and use of personal pronouns such as "we" (identified by 2 teachers). Other unknown interactional skills mentioned by the teachers included placeholder words, poetic language, body language, and phatic talk (each identified only once by different teachers). Overall, the teachers' responses to this question indicate that their awareness of teacher-student interaction, which initially seemed limited to questioning, increased substantially during the two weeks of the SMIT'N institute. Evidence of such is provided by the following quotation:

> Teacher 12: Each day I found something that we discussed in my teaching i.e. using lots of 'we' statements.

Thirteen teachers agreed that what they learned about teacher-student interaction would indeed help them improve their ability to teach science through inquiry. Evidence of such can be found in the following quotations from the teachers' responses to question 5:

> Teacher 3: Yes, I am <u>more aware</u> of how I interact with my students.

> Teacher 9: Yes, it will make me <u>more aware</u> of them [teacher-student interactions] in the future.

> Teacher 10: Yes, I think I will be more <u>careful and thoughtful</u> with my questioning and responding. I will also be <u>cautious</u> of my use of poetic language.

> Teacher 12: Yes, because I will be more <u>aware and conscious</u> of what I'm saying.

> Teacher 13: Yes, the information I have learned has made me more <u>self-aware</u> of my questioning strategies and the language I use.

> Teacher 15: Yes, very much so. I am now <u>overtly cognizant</u> of the words we all use in general conversation and how inadvertently or at times intentionally lead us. This is invaluable information for a teacher to understand and model to young children.

As highlighted above, teachers' responses leave little doubt that their participation in the SMIT'N institute led to a substantial increase their awareness of language use and social interaction in inquiry-based classroom settings. Furthermore, there seems to be a consensus among the participating teachers that their increased interactional awareness will help them become more effective while implementing classroom inquiries. In other words, by becoming more aware of teacher-student interaction, the teachers felt encouraged to continue to reflect about and strive for improvements in their use of language and interactional practices while engaged in classroom inquiries.

Question 7 asked teachers whether they considered any of the several interactional skills discussed in the SMIT'N institute to be irrelevant to their overall ability to teach science through inquiry. Most teachers responded negatively except three kindergarten teachers who replied:

> Teacher 7: Poetics. Too much sarcasm for the little guys. They don't understand it.
>
> Teacher 11: Poetic talk – doesn't pertain to K-1.
>
> Teacher 12: The poetic aspect, some parts were relevant although many were not for my specific grade level.

As indicated above, the kindergarten teachers considered poetic language to be of limited utility for their inquiry-based teaching ability, an assessment that is justified in terms of their perceptions of linguistic constructions such as sarcastic comments as being beyond primary pupils' linguistic abilities, and thus incomprehensible to the younger students.

Teachers were also asked to identify aspects of teacher-student interactions that were not included in the institute and interactional skills that they would to learn more about (question 9). Eleven teachers thought that the institute was very comprehensive and only four requested more information about particular interactional skills such as phatic language, questioning, responding, and giving directives. It must be noticed that the institute placed strong emphasis on questioning and responding skills (three entire days were devoted to the former, whereas two days were devoted to the latter), yet teachers requested even more information about these two interactional skills. Such requests underscore the importance that questioning and responding have for effective inquiry-based science teaching.

Only one teacher identified an aspect of teacher-student interaction that was not addressed in the institute (question 8):

> Teacher 8: We never talked about how students with language or communication disabilities might fit into interactional patterns, etc. or how students of different cultures may impact our language use or awareness.

The above teacher identifies an important limitation of the SMIT'N summer institute, which is the excessive attention paid to raising teachers' awareness of mainstream patterns of language use and teacher-student interaction. In fact, little information was provided about communicative skills that teachers could use to interact specifically with disable students and minority groups.

Summary

A comparative examination of teachers' initial and final interactional views revealed that the SMIT'N summer institute encouraged participants to develop a new conception of inquiry-based science instruction centered on classroom discourse and teacher-student interaction. Elementary teachers who once tended to overlook the social or interactional dimension of inquiry-based science teaching (focusing instead on student cognition and non-discursive pedagogical strategies) developed an increased awareness of and ability to articulate the potential social implications of the language they used to address students engaged in classroom inquiries.

Prior to participating in the institute, elementary teachers either overlooked or had difficulty articulating social aspects of inquiry-based science instruction, focusing mainly on nonverbal characteristics of their classroom inquiries. More specifically, pre-institute teachers (1) tended to define the interactional roles played by them and their students in terms of the adoption of general, non-discursive teaching and learning activities; (2) were unable to articulate what type of social relationship they sought to establish with their students during classroom inquiries (3) were unable to articulate the social structure(s) of their inquiry science lessons; (4) were unable to articulate interactional differences between traditional lectures and classroom inquiries; and, (5) tended to focus mainly on communicative (in)abilities related to the management of student cognition and thinking, at the same time neglecting communicative skills needed for effectively coping with the complex socio-emotional demands of inquiry-based science teaching.

In sharp contrast, post institute teachers developed a language-centered view of inquiry-based science instruction. More specifically, elementary teachers (1) reported having developed an increased level of linguistic awareness; (2) were able to articulate inquiry-based science teaching in terms of the establishment of more symmetric and open forms of teacher-student social relationships; (3) demonstrated an increased awareness of responding as an essential communicative skill; (4) became more aware of the potential social implications (both positive and negative) of the different types of questions they usually ask their students; (5) became more aware of socio-emotional interactional skills such as being polite while giving directives to students, using the second person pronoun “we” to foster inclusiveness in their classrooms, and using poetic language to promote student involvement; and (6) became aware of interactional issues previously unknown to them, including hedges and discourse structures such as IRE and IRF.

Similarly, examination of teachers’ emergent interactional views suggested a gradual shift from a cognitive, monofunctional and decontextualized perspective on inquiry-based classroom discourse to a stance that took into account the social, multifunctional and contextualized nature of the language used by teachers to address students while implementing classroom inquiries. Rather than continuing to view teacher-student verbal exchanges as serving exclusively cognitive ends (i.e., promoting and supporting student scientific thinking), participants were gradually able to recognize that teachers and students’ speech behaviors also serve multiple interactional functions, thus providing a dynamic social context or structure for students’ scientific thinking and learning.

While participating in the summer institute, participants articulated a language-centered view of teachers' questions emphasizing that (1) in some social contexts, students can perceive teachers' questions as being ill-intentioned and insincere; (2) if asked in a threatening and unsupportive social context, teachers' questions can inhibit student participation and aloud thinking; (3) teachers can encourage their students to focus on articulating their own thinking rather than on providing the right answers by asking you-questions; (4) adoption of formative assessment can allow teachers to ask higher numbers of you-questions; (5) teachers' rhetorical questions can serve cognitive functions such as probing beyond what is currently known to science as well as interactional functions such as fostering student involvement, helping students develop less negative feelings about not knowing the answers, narrowing the social gap that separates students from teachers and scientists, improving students' views of science, and motivating students to investigate and read; and (6) teachers can depress student participation and engagement by asking pseudo-questions that encourage students to attempt to read the teacher's mind or to state what seems to be obvious.

With regard to discourse structures, participants' emergent views emphasized that (1) IRE sequences create the impression of a "quiz show," whereas IRF sequences enable teachers to extend students' responses and encourage their participation; (2) teachers' third moves can be multifunctional, that is, they can simultaneously serve as Evaluation and Feedback; (3) IR sequences can confuse students and encourage them to try to read the teacher's mind; (4) teachers can evaluate students through nonverbal channels; (5) teachers only make a Feedback move when they provide students with scientific information and encourage their thinking; (6) guiding and evaluating are not mutually exclusive discursive practices; and (7) when guiding, teachers should concentrate their efforts on providing feedback to students rather than on withholding evaluations from them.

Participants' emergent interactional views of teachers' questioning approaches emphasized that (1) cued elicitation can encourage students to guess what the teacher has in her mind; (2) retrospective elicitation can be perceived as being good- or ill-intentioned; (3) convergent questioning approaches such as Socratic questioning can enable teachers to avoid student digressions and save teaching time; (4) leading questions can be potentially used by teachers to support students with limited observational and communicative skills; and (5) the referential contents of teachers' questions can provide students with implicit evaluative feedback.

Participants also articulated sophisticated views of hedges as multifunctional and contextualized discursive devices, emphasizing that (1) teachers can resort to attribution shields in order to encourage students to participate in classroom discussions, acknowledge students' expertise, and avoid evaluating students' contributions; (2) teachers can employ adaptors at the beginning of classroom inquiries to motivate students to inquire and look for their own answers; (3) teachers often allow students to hedge orally but not in writing, creating a disjoint in classroom communication; (4) students' use of hedges indicates tentativeness and uncertainty about science; (5) students are expected to use hedges and vague language during the Engage and Explore phases of the learning cycle, but not after being introduced to scientific terminology in the Explain phase; (6) students resort to hedging in order to avoid committing to their responses and to defend themselves from failure; and (7) children's hedging tends to be interpreted as nervousness and fear of teacher disapproval, whereas adults' hedging is more likely to be interpreted as lack of preparation.

With regard to teachers' reactive speech behaviors, participants emergent interactional views emphasized that (1) excited or surprised teacher reactions can serve an affirmative interactional function; (2) teachers' explicit positive evaluations early in inquiry science lessons can depress student engagement in classroom discussions and investigations; (3) verbatim repetition of students' responses can discourage student-student verbal communication; (4) verbatim repetitions can serve positive interactional functions such as marking students' contributions as being important and "giving a voice" to students who are non-native speakers of English; (5) teachers repeat students' responses in order to display their listenership to students; (6) teachers' repetitions of students' responses can serve an "endorsing" discursive function; (7) written repetitions of students' responses can be more strongly endorsing than spoken repetitions; (8) teachers can avoid endorsing students' responses by resorting to explicit disclosure of tentativeness and neutrality; and (11) teachers can repeat students' misconceptions or wrong answers provided that they encourage students to reconsider at the end of inquiry science lessons.

Participants' emergent views of personal pronouns highlighted that (1) teachers' use of the singular "you" can make classroom interactions become more focused on individual students' competence and ability to investigate than on the investigation itself; (2) teachers can avoid using the singular "you" by having students work in small groups; (3) teachers can use the plural "you" to promote student agency, accountability and independence; (4) teachers can use the inclusive "we" to create a supportive classroom atmosphere and to prevent students from feeling helpless or neglected during classroom inquiries; (5) teachers can use the inclusive "we" to promote group cohesiveness and solidarity in the classroom; (6) if overused, the inclusive "we" can create the impression that the teacher lacks authority and management skills; and (7)

“I/you” contrastive pairs can encourage students to focus on the right answers and to perceive the teacher as an authority.

With regard to directives, participants’ emergent views emphasized that (1) polite directives are appropriate for dealing with ordinary classroom situations; (2) teachers can use polite language to model good or acceptable interactional behavior to students; (3) effective management of student misbehavior can require teachers to employ objective and impolite directives; (4) recurring student misbehavior can be handled with directives that are increasingly objective and impolite; (5) teachers can deal with student misbehavior indirectly by highlighting the transgressors’ inability to listen; (6) teachers’ can give directives that draw attention to well-behaved students instead of transgressors; (7) personal requests are more effective at lower grade levels; and (8) the relative level of politeness of a directive can vary depending upon the teacher’s tone of voice.

Lastly, with regard to poetics, participants’ emergent views emphasized that (1) teachers’ poetic language can serve motivational functions such as promoting student involvement, engagement, and excitement; (2) teachers’ poetic language can serve cognitive functions such as increasing student recall of scientific information; and (3) teachers’ poetic language can confuse elementary students, especially non-native English speakers and students at lower grade levels.

Chapter 5

RESULTS: TEACHERS' PRACTICES OF CLASSROOM INQUIRY

Introduction

Presented in this chapter are the findings of a microethnographic analysis conducted to characterize and compare elementary teachers' interactional strategies and discursive practices before and after participating in the SMIT'N summer institute. The text is divided into three main sections, each focused on the interactional or discursive strategies adopted by a particular elementary school teacher -- Teacher 7 (kindergarten), Teacher 4 (fourth grade), and Teacher 15 (fourth grade) sequentially. Each section contains descriptions and illustrative examples of how a particular teacher tended to interact with students while implementing inquiry science lessons in their classrooms prior to SMIT'N (i.e., *pre-institute interactional strategies*) as well as comparative analyses of verbal interactions between the same teacher and her students while engaged in classroom inquiries subsequent to SMIT'N (i.e., *post-institute interactional strategies*). Combined, the results reported in these three sections provide an answer to the second research question outlined in Chapter 1 (i.e., *how did the institute on teacher-student interaction influence inquiry-based science teaching in elementary schools?*).

It will be convenient to clarify in this introductory section what is being implied in my use of the term "classroom inquiry." Like most science educators, my view of classroom inquiry is guided by the framework provided by the National Science Education Standards (NSES; NRC, 1996). More specifically, all inquiry science lessons I analyze in this chapter fit Bell and his colleagues' perspective on the meaning of inquiry:

> At its heart, inquiry is an active learning process in which students answer research questions through data analysis. One might argue that the most authentic inquiry activities are those in which students answer their own questions through analyzing data they collect independently. However, an activity can still be inquiry based when the

> questions and data are provided, as long as students are conducting the analysis and drawing their own conclusions. (Bell, Smetana, & Binns, 2005, p. 31)

In all inquiry science lessons, students are engaged by scientifically oriented questions; use evidence to formulate explanations; evaluate explanations in light of scientific understandings; and communicate and justify their explanations. These particular practices are consistent with what has been defined as the ‘‘essential features of classroom inquiry’’ (NRC, 2000, p. 25). However, it must be noted that the inquiry science lessons are not "open" (NRC, 1996) for elementary teachers determine the focus of the investigations and provide students with questions that direct their attention to important factors and content issues that need to be addressed in the investigative experiences.

The following notation is adopted in all transcript excerpts included in this chapter: rising intonations are indicated by ?; falling intonations are indicated by .; stress is indicated by CAPS; interruption or next utterance following immediately is indicated by =; periods of silence to the nearest second are indicated by (1.0); the moment of overlap between concurrent utterances is marked by [; observer comments are indicated by (( )); and, <u>underlining</u> is used to identify key linguistic features of the provided excerpts. Pseudonyms are used for all participating students.

Teacher 7's Inquiry-Based Discourse

Pre- Institute Interactional Strategies

Prior to the SMIT'N institute, Teacher 7 was video-recorded while implementing a classroom investigation on the development of chicken eggs and growth of chick embryos. Her investigative activity was based on an inquiry-based science lesson entitled "*Eggs and Chicks*" which is part of the FOSS Animals Two by Two Module for Kindergarten (Lawrence Hall of Science, 2005). As part of this life science lesson, Teacher 7 and her students set up a class incubator -- a still-air incubator heated by a short table lamp -- with a large picture window on the top and a thermostat. By monitoring the incubation of over a dozen fertilized eggs for a period of 21 days, students were encouraged to observe changes in the structure of growing chick embryos, learn that chicken eggs require certain environmental conditions to hatch, and observe chicks hatching from eggs. The classroom interactions analyzed below took place on the ninth day of incubation. With her students (approximately twenty kindergarteners) sitting on the floor, Teacher 7 facilitated a whole-class discussion in which she asked students to describe what they had observed in previous days, showed them a chart with pictures of the developmental stages of a chick (from an unincubated egg to a 21-day embryo), and then asked them to make new observations of the incubated eggs - held by her against the light of a slide projector (Figure 5.4).

Figure 5.4 – Teacher 7 showing incubated eggs to kindergartners.

While interacting with her students, Teacher 7 tended to adopt authoritative discourse strategies that led to the establishment of an asymmetric social structure. Predominantly, Teacher 7's linguistic choices seemed to have a distancing interactional effect, resulting in the creation of social divide between herself (the knowledgeable expert) and her students (the novices seeking knowledge). One of the most noticeable authoritative discourse strategies frequently employed by Teacher 7 was to provide her students with explicit and emphatic positive evaluations. The four excerpts provided below (taken from different parts of the whole-class discussion) illustrate Teacher 7's frequent employment of this particularly authoritative discourse strategy:

> Teacher 7: Well, boys and girls, what have we been studying in here?
> Students: CHICK, CHICK EGGS.
> Teacher 7: Chick eggs, <u>you are absolutely right</u>.
>
> Teacher 7: How many ((days of incubation)) did you count? Melissa.
> Melissa: Nine.
> Teacher 7: <u>You are absolutely right</u>.
>
> Teacher 7: Do you think that shadow ((inside the egg)) is lighter, or darker, bigger, smaller? Carlson.
> Carlson: Bigger.
> Teacher 7: <u>You're absolutely right</u>.
>
> Teacher 7: Okay, remember, are you gonna look at this light ((the slide projector))?
> Student: No, because it will hurt our eyes.
> Teacher 7: It will kinda hurt your eyes, <u>you are absolutely right</u>.

In all of the above excerpts, Teacher 7 adopts the same authoritative interactional pattern. First, she makes the initiation move by posing a display question (a query whose primary function is to test students' knowledge rather than a genuine request for information unknown by her). More importantly, Teacher 7 invariably follows each of her students' short responses ("*nine*," "*bigger*") to her questions with explicit and emphatic positive evaluations ("*you are absolutely right*"), sometimes also repeating their answers verbatim ("*<u>chick eggs</u>, you are absolutely right*"). As a result, teacher-student interactions take the form of IRE sequences, with Teacher 7 continuously positioning herself as a knowledgeable authority with superordinate interactional rights such as testing and evaluating others' contributions to the whole-class responses. In contrast, students only hold the subordinate right of offering short responses to Teacher 7's scrutiny, remaining trapped in between her two authoritative moves (i.e., her display question and explicit evaluation).

The above excerpts also illustrate a second authoritative discourse strategy frequently used by Teacher 7 which is her preference for the distancing personal pronoun "*you*" over the solidarity-building pronoun "*we*." With the exception of her first display question ("*what have <u>we</u> been studying in here?*"), Teacher 7 employs the pronoun "*you*" in all her questions and evaluative comments, thus distancing herself from the students rather than creating social proximity with them. This preference for the distancing "*you*" was observed throughout the whole-class discussion, with the first-person pronoun "*we*" being used only sporadically by Teacher 7.

Another authoritative discourse strategy employed by Teacher 7 while facilitating the whole-class discussion was to provide explicit negative evaluations. This particular strategy was often used by Teacher 7 when she adopted a questioning approach focused on student recall of scientific words previously mentioned by her:

> Teacher 7: Does anybody remember the word that <u>I</u> kinda called this? <u>Say it Diana</u>.
> Diana: They are ((inaudible)).
> Teacher 7: <u>No</u>, look at this egg, it has those little bittie spots, do you see all those tiny dots? There is a particular work I call this kind. <u>It starts with a P</u>. Do you remember, Travis?
> Travis: Chick?
> Teacher 7: <u>NO::</u>, Preston.
> Preston: Popcorn ((laughs))
> Teacher 7: <u>No</u>, these types of eggs are kind of porous.

Teacher 7 initiates the above interactions by asking a display question ("*does anybody remember the word that <u>I</u> kinda called this?*"). It must be noticed that Teacher 7 employs the personal pronoun "*I*" while asking her question, thus foregrounding her authoritative social status. Implicitly, Teacher 7 seems to be asking "what word did I (the authority) use before?" Furthermore, Teacher 7's question is immediately followed by a direct directive, more specifically an imperative statement ("*say it Diana*") that reinforces her authoritative interactional role. Teacher 7 appears to be giving Diana a direct order or command rather than a more indirect and polite request for a response. More importantly, each of her students' responses is followed by an explicit negative evaluation ("*no*") indicating that the students have failed to provide the right answer. After her first student fails to remember the word she is looking for, Teacher 7 resorts to cued elicitation by providing verbal clues such as "*this egg has those little bittie spots*" and "*it starts with a P*." As a result, teacher-student interactions start to resemble a guessing game which encourages her student Preston to humorously offer an off-the-wall response ("*popcorn*"). Faced with her students' inability to remember (or guess) the scientific word she has in mind, Teacher 7 decides to go ahead and reveal it ("*porous*").

In other instances, rather than providing explicit negative evaluations, Teacher 7 reacted to her students' failed attempts to answer her questions by hedging. Such discursive strategy usually took the form of vague comments that seemed to serve as implicit negative evaluations:

Teacher 7: Does anybody remember what those kind, those little lines are called? Yes.
Student: Vines.
Teacher 7: ((smile)) Vines? <u>You are abs</u>, <u>you are so close</u>, <u>very close</u>, <u>it's not quite vines</u>, it <u>does start with a V</u> ((students raise hand)) Aliah.
Aliah: They are called veins.
Teacher 7: VEINS, they are the veins.

Teacher 7: Does it ((the drawing of a nine-day chick embryo)) look like a chick?
Students: Yeah
Teacher 7: <u>Yeah? UMM ((looking at the picture with an intrigued facial expression)), you guys have a good imagination.</u>

Teacher 7: Do you see much of anything in this egg?
Student: I see a mouth.
Teacher 7: <u>A mouth, really? I don't know</u>.

Teacher 7 initiates each of the three sequences shown above by asking display questions, more specifically convergent questions with a yes-or-no format aimed primarily at testing students' recall and observational skills ("*does anybody remember what those little lines are* *called?*", "*does it look like a chick?*", "*do you see much of anything in this egg?*"). When her students fail to provide the responses she expected, Teacher 7 reacts by uttering vague comments such as "*it's not quite vine*," "*you guys have a good imagination*," and "*I don't know*." Despite their vagueness, it is clear that such comments still serve an evaluative function. By hedging rather than providing more explicit negative evaluations in the third move of IRE sequences, Teacher 7 avoids appearing authoritarian. As a result, Teacher 7 is able to momentarily decrease her authoritative social status perhaps to compensate for the authoritative interactional effect of her frequent explicit evaluations.

Likewise, Teacher 7 did not always provide explicit positive evaluations to her students, choosing sometimes to simply repeat their responses verbatim. Nonetheless, her verbatim repetitions clearly had an evaluative function, more specifically serving as implicit positive evaluations. Teacher 7 adopted such discursive strategy soon after her student Aliah pointed out that the lines seen inside the incubated eggs were called veins:

Teacher 7: Does anybody know what those veins do for that little chick? Ryan.
Ryan: Maybe, umm, to get them, umm, help them breath?
Teacher 7: <u>To help 'em breath</u>, possibly. What else do you think veins do? Halie.
Halie: To help the chicks, keep 'em warm.
Teacher 7: You think veins help chi, <u>chicks stay warm</u>, okay. Jordan.
Jordan: To help, help them grow.
Teacher 7: <u>To help them grow</u>. These are all really good thoughts. Caleb.
Caleb: Umm, to help them get blood.
Teacher 7: Oh, <u>veins help you get blood</u>.

Like in previous instances, Teacher 7 starts the discussion by asking a yes-or-no display question ("*does anybody know what those veins do for that little chick?*"). Such question initiates what seems to be a brainstorming session wherein several students take turns entertaining potential biological functions for the observed veins. As indicated above, Teacher 7 continues to repeat each of her students' responses verbatim ("*to help 'em breath*," "*chicks stay* *warm*," "*to help them grow*," "*veins help you get blood*"). It can be argued that such verbatim repetitions have an implicit evaluative function. By repeating, Teacher 7 endorses her students' responses (i.e., she is verbally highlighting their correctness). Despite the indirectness of many of Teacher 7's reactive moves, an evaluative tone persisted throughout the whole-class discussion. For the most part, students seemed more concerned with what could possibly be the correct answers and observations being requested by the knowledgeable authority (Teacher 7) than articulating plausible ideas of their own based on the available evidence.

As indicated above, Teacher 7 tended to adopt an authoritative questioning approach more focused on student recall of scientific words (e.g., "*porous*," "*veins*") than on student thinking or reasoning. Teacher 7 also tended to focus on the words used by her students to describe their observations. This particular discursive practice was adopted when her student Caleb tried to point out that the dot inside one of the incubated eggs (i.e., the chick embryo) was getting bigger over time:

> Teacher 7: You see a little dot. Caleb, what about that dot?
> Caleb: Big.
> Teacher 7: What big? Is the dot=
> Caleb: It grew that big.
> Teacher 7: So, it is getting <u>bi::</u> ((separating her two hands))
> Students: GER, bigger.
> Teacher 7: Bigger.

Teacher 7's questions ("*what about that dot?*", "*what big?*") are aimed primarily at encouraging Caleb to elaborate his observation which is initially limited to a vague reference to a dot. Noticing that Caleb is having some difficulty articulating his observation, Teacher 7 then resorts to a verbal cloze ("*bi::*") and to a gestural cue (increasing the distance between her two hands) in order to encourage Caleb and other students to utter the word "*bigger*." It must be noticed that the primary of focus of Teacher 7's questioning is to simply stimulate students recall isolated words rather than articulating their thoughts or ideas; Caleb and other students do not actually employ the word "*bigger*" to articulate their observation in the form of a complete sentence (e.g., "the dot is getting bigger").

Another authoritative discourse strategy adopted by Teacher 7 while facilitating the whole-class discussion was to ignore topics introduced by some of her students. For instance, during the discussion about the biological functions of veins a student uttered the following twice "*and when they* [veins] *are purple=,*" thus attempting to introduce the idea that the colors of veins may have some relevance to their biological functions. However, in both instances the student was interrupted by Teacher 7 who immediately redirected students' attention to the chart showing the developmental stages of a chick embryo. Similarly, while Teacher 7 was holding the last incubated egg against the light, a student asked her twice "*doesn't that light hurt the chicks' eyes?*" In the second time, Teacher 7 simply responded with a negative shake of head and then immediately requested students to provide her with more observations. By repeatedly laying claim to the superordinate interactional right to select the topics being introduced to the discussion, Teacher 7 verbally highlighted her authoritative social status to students.

Teacher 7's use of personal pronouns changed drastically while giving directives to individual students. Instead of the detached and distancing pronoun "you," Teacher 7 tended to resort to the solidarity-building "*we*." Such directive behavior was adopted for instance when Teacher 7 showed the diagram of the developmental stages of a chick embryo to her students. While holding the diagram in her hands, Teacher 7 uttered "*this is day, those were, this was six, seven and eight, so now let's, <u>let's look at day nine</u>. Day nine is this very first one. What do you see happening? How is it different?*" Despite her imperative statement ("*let's look at day* *nine*"), several students continued to make observations about other days, forcing Teacher 7 to keep giving them directives to focus specifically on the ninth day of incubation:

Student: Day eleven is bigger
Teacher 7: We are not looking at day eleven.

Preston: Uh:, I think that the egg is getting littler, littler space, and littler space on day twelve.
Teacher 7: Well, honey, we are only on day 9, okay?

Mary: ((gets up and touches the chart)) I see that one, that's, that egg.
Teacher 7: Honey, we are looking at this one right here.

Teacher 7 follows each of her students' failure to comply with her initial directive ("*let's look at day nine*") with a declarative statement. It should be noted that Teacher 7 employs the solidarity building pronoun "*we*" in all of her declaratives. Furthermore, two of her declaratives are prefaced with the term of endearment "*honey*." Both of these discursive strategies serve a politeness function, that is, they constitute linguistic devices aimed primarily at saving students' face by creating the impression of social proximity and interactional affection. As result, Teacher 7 is able to maintain control over her students' contributions to the discussion and to avoid digressions without appearing authoritarian.

Similarly, Teacher 7 tended to resort to first-person pronominal forms while giving whole-class directives. Such tendency was apparent toward the end of the inquiry lesson when a male student disrupted the discussion by repeatedly asking Teacher 7 to hold an egg with excremental residue on its shell against the projector light (students had noticed in a previous class that some of the eggs had chicken excrement on them):

Teacher 7: We will look at one more egg and that's it for today.
Student: Get the poopie one.
Teacher 7: I don't wanna touch the poopie eggs.
Students: Ew:: You can use gloves for them.
Students: Nah, that's disgusting. That's stupid.
Teacher 7: Okay, we don't need to talk about those eggs.

Teacher 7 starts off the above interactions with the declarative command "*we will look at one more egg and that's it for today*." Immediately, one of her students asks her to show them a "*poopie egg*," a request supported by some and opposed by other students, thus starting an argument. In response to this disruptive request, Teacher 7 gives two declarative directives. First, Teacher 7 attempts to end the argument by simply declaring her personal desire not to touch the eggs ("*I don't wanna touch the poopie eggs*"). However, her directive is too indirect and the students continue to argue over which egg to look at next. The argument only comes to an end when Teacher 7 gives a more direct declarative ("*we don't need to talk about those eggs*"). As underlined, Teacher 7 seems to compensate for the increased level of directness of her second directive through strategic employment of the solidarity-building pronoun "we."

Another polite directive behavior adopted by Teacher 7 while dealing with student misbehavior was positive reinforcement. This particular directive strategy was employed by Teacher 7 when she asked her students to identify parts of their bodies where veins were visible, a request that encouraged the students to suddenly start talking to each other, thus disrupting the ongoing discussion:

> Teacher 7: Where can you can kinda see your veins?
> Students: Right here, at your wrist ((point to their own wrists))
> Teacher 7: Oh::::! Yep, you can see= Boys and girls ((students continue to talk)) Oh, I like the way Travis is sitting ((students continue to talk)) Oh, I like the way Hanna is sitting ((students stop talking)) Thank you. You are absolutely right, sghh ((to a student who starts talking again)) you can see your veins here, now Caleb said, excuse me ((to the same student who continued to talk)).

As can be seen above, Teacher 7 gives a series of directives while attempting to get her students to discontinue their disruptive behavior. Her first whole-class directive is an imperative that takes the form of a verbal ellipsis (Holmes, 1983) in which the generalized term "*boys and* *girls*" is used as directive to "stop talking." When students fail to comply, Teacher 7 then resorts to positive reinforcement by uttering declaratives that draw attention to students who are displaying what she considers to be good behavior ("*I like the way Travis is sitting*," "*I like the way Hanna is sitting*"), thus keeping student misconduct in the background. Teacher 7 also employs polite formulae such as "*thank you*" and "*excuse me*" as well as the nonverbal imperative "*sghh*." Adoption of such discursive strategies illustrates Teacher 7's tendency to position herself non-authoritatively while giving directives to her students by favoring linguistic politeness and indirectness.

Post-Institute Interactional Strategies

After the SMIT'N summer institute, Teacher 7 was video-recorded for a second time while conducting a classroom investigation on the physical properties of different types of fabrics. Her inquiry activity was based on a lesson entitled "*Fabric All Around*," which is part of the FOSS Fabric Module for Kindergarten (Lawrence Hall of Science, 2005). At the beginning of her inquiry lesson, Teacher 7 facilitated a whole-class discussion in which she sought to elicit her students' prior knowledge by asking them to explain what fabric was and to identify common objects made of fabric. In the second part of the lesson, Teacher 7 provided her sixteen kindergartners with samples (10 cm blue squares) of a variety of fabric types, including burlap, corduroy, denim, fleece, knit, nylon, organza, satin, seersucker, terry cloth and muslin. Working in pairs, students were asked to observe the properties of a particular type of fabric and to describe how it could be possibly used. Finally, at the end of the lesson, Teacher 7 facilitated another whole-class discussion in which she asked each pair of students to share their observations and explain to classmates how they thought each type of fabric could be made useful (Figure 5.5). The discourse analysis provided below focuses exclusively on the interactional structure of the two whole-class discussions, which are systematically compared to the pre-institute whole-class discussion about incubated eggs.

Figure 5.5 – Teacher 7 showing a piece of fabric to kindergartners.

Throughout the whole-class discussions, Teacher 7 employed discursive strategies that were substantially less authoritative than those she had utilized prior to participating in the summer institute. By positioning herself interactionally closer to her students, Teacher 7 was able to effectively foster a more symmetric classroom social structure in which authority was strategically shared with her students. To establish this more egalitarian teacher-student social relationship, Teacher 7 relinquished the right to provide explicit and emphatic positive evaluations to students (her pre-institute discursive strategy), opting instead for the provision of more implicit forms of evaluation such as verbatim repetitions of students' responses. For instance, at the beginning of the classroom investigation, Teacher 7 asked her students if they knew what fabric was, subsequently reacting to their responses by offering verbatim repetitions:

Teacher 7: Does anybody know what fabric is? ((sincerely interested tone)) Jena.
Jena: You make blankets.
Teacher 7: Oh, <u>blankets</u> are a type of fabric! What else can be fabric? ((sincerely interested tone))
Autumn: A dress.
Teacher 7: <u>A dress.</u>
Student: A skirt.
Teacher 7: Or <u>skirt</u>, okay, umm, Jonathan.
Jonathan: Pillow.

Teacher 7: Your <u>pillow</u> is fabric.

As indicated above, Teacher 7 employs a particularly emphatic tone while posing questions to students ("*does anybody know what fabric is?*" and "*what else can be fabric?*"), skillfully marking her queries as sincere requests by creating the impression that she truly wants to know what fabric can possibly be. In response, her students start identifying common objects they consider to be made out of fabric ("*blankets*," "*dress,*" "*skirt*," "*pillow*"). It must be noticed that Teacher 7 invariably follows each of her students' responses with a verbatim repetition, a discursive move that serves both acknowledging and evaluative interactional functions. Not only does Teacher 7 acknowledge her students' contributions to the discussion but she also indirectly marks such contributions as constituting adequate or appropriate responses to her questions. In other words, Teacher 7's verbatim repetitions of students' responses serve as implicit positive evaluations. Unlike in the whole-class discussion she facilitated prior to the summer institute, Teacher 7 this time did not provide explicit positive evaluations (e.g., "*you are absolutely right*"), choosing instead to employ only implicit evaluative forms.

Similarly, Teacher 7 tended to provide implicit negative evaluations to her students, and for the most part avoided the use of more explicit forms of negative evaluative comments. Such indirect evaluative practice was used particularly often during the second whole-second class discussion, when Teacher 7 asked each student pair to share their observations of the physical properties of fabric samples and to identify their potential utility. Two distinct moments of the discussion are included below:

Teacher 7: Describe to me what it's [the fabric] like.
Taylor: Rough.
Teacher 7: <u>Rough?</u> ((gently rubs it on the student's face)) Is it rough?
Taylor: No, it's soft.
Teacher 7: It's soft.

Teacher 7: What could you use this fabric for?
Emma: Blanket.
Teacher 7: <u>A blanket?</u> Well, is this thick enough to be a blanket?
Emma: ((shakes her head negatively))

In the first excerpt, Teacher 7 asks her student Taylor to describe his fabric sample to her, encouraging him to provide the one-word response "*rough*." Teacher 7 then immediately reacts by uttering a verbatim repetition with a rising intonation ("*rough?*"), rubbing the fabric gently on his face, and then asking a yes/no question ("*is it rough?*"), clearly encouraging Taylor to reconsider his previous response. When Taylor changes his response, Teacher 7 then provides a second verbatim repetition, this time with a falling intonation ("*it's soft*"). It must be noticed that Teacher 7 avoids explicit evaluations (both negative and positive), resorting instead to implicit evaluations that take the form of verbatim repetitions with distinct intonations. More specifically, she marks her negative evaluative comment with a rising intonation, whereas her positive evaluations are uttered with a falling intonation. A similar pattern can be observed in the second excerpt. When Teacher 7 asks a question ("*what could use this fabric for?*"), her student Emma replies the word "*blanket*." Teacher 7 then repeats her response with a rising intonation ("*blanket?*") and then challenges Emma's idea by asking a yes/no question ("*is this thick enough to be a blanket?*"), encouraging Emma to immediately alter her previous response.

The inflectional demarcation of Teacher 7's implicit evaluative comments was not always clear cut. Sometimes Teacher 7 uttered verbatim repetitions with rising intonations that seemed to serve a relatively neutral acknowledging function, thus blurring the distinction between her implicit positive and negative evaluative messages. This more neutral reactive behavior was employed by Teacher 7 while student pairs were sharing their observations with rest of the class:

Teacher 7: What's this stuff good for?

Student: Uhh, for a blind?
Teacher 7: A blind?
Student: No, umm, it's a scarf.
Teacher 7: A scarf?
Student2:   Maybe a washrag.
Teacher 7: A washrag.

Teacher 7: Well, describe it to me. Is it soft, is it thick, is it thin?
Emma: It's=
Shawn: Soft.
Teacher 7: [Soft?
Emma: [Thin.
Teacher 7: And, it's thin? Soft and thin?

As underlined above, Teacher 7 reacts to several of her students' responses by providing verbatim repetitions with rising intonations ("*a blind?*" "*a scarf?*" "*soft?*" "*soft and thin?*"). Nonetheless, in only one occasion the student who responds interprets such discursive move as an implicit negative evaluation, immediately changing his response from "*a blind*" to "*a scarf*." Such interactive pattern suggests that employment of rising intonation does not necessarily render all of Teacher 7's verbatim repetitions the status of implicit negative evaluations; some of her repetitions are actually neutral. Such neutrality seems to stem from the fact that, unlike in the previous two excerpts, Teacher 7 utters her rising verbatim repetitions without following them with challenging questions aimed at encouraging students to reconsider their responses. As a result, Teacher 7's rising verbatim repetitions acquire a more neutral character as mere reactive moves aimed primarily at making sure that she heard their students' responses right (as opposed to challenges to the contents of students' responses). In other words, Teacher 7's implicit negative evaluations are performed through a combination of rising verbatim repetitions and follow-up questions.

Adoption of the above discursive strategies is a direct consequence of Teacher 7's participation in the SMIT'N institute. For instance, the issue of linguistic insincerity of teachers' questions was discussed extensively on the second day of the institute. As described in Chapter 4, it was emphasized to participants that in order to be considered genuine or sincere, a question needs to meet certain sincerity conditions, one being that the person who poses a question would truly like to know the answer (Labov, 1970). Teacher 7 is implementing precisely such an interactional view by resorting to an intonation that creates the impression that she is sincerely interested in learning the answer to the question she is posing. Likewise, the need for teachers to avoid evaluating their students' responses explicitly was also discussed on the second day of the summer institute. Such evaluative practice, participants argued, especially early in the lesson, can discourage students from engaging in classroom investigations. This emergent interactional view is likely to be the reason behind Teacher 7's avoidance of explicit evaluations subsequent to the institute.

In addition to avoiding explicit oral evaluations, Teacher 7 also tended to adopt a student-centered questioning approach focused mainly on encouraging her students to evaluate themselves and each other. Teacher 7 adopted this non-authoritative line of questioning several times during the classroom investigation. Included below are two of such instances. The first one occurred early in the lesson when Teacher 7 asked her students to name items they thought were made out of fabric, whereas the second excerpt occurred toward the end of the lesson while students were sharing their observations and inferences with regard to their fabric samples:

> Teacher 7: What else besides clothes we wear are made out of fabric? Can you think of any other things?
> Jonathan: Snow.
> Teacher 7: Jonathan, <u>how is SNOW fabric?</u>
> Jonathan: Well, because ice is under it.
> Teacher 7: Is ice, <u>do you think ice is fabric?</u> ((skeptical tone))
> Student: No.
> Jonathan: Umm, snow, it has fabric in it.
> Teacher 7: <u>What is snow made out of?</u>
> Students: WATER

Teacher 7: Water, is water a fabric?
Students: No, nope.
Teacher 7: Can you really wear water?
Student: No.
Teacher 7: NO::: I don't think I would consider water fabric.

Payton: It could be like these shoes, right here ((points to his shoes)).
Teacher 7: Oh, it could be used on the top part of your shoes! Would it be very good at keeping water out? ((skeptical look))
Payton: No::
Teacher 7: So, would that probably be a good idea? I want my shoes to keep my feet dry, I don't know about you.

As can be seen above, Teacher 7 does not provide an explicit negative evaluation when her Jonathan unexpectedly identifies snow and ice as being made of fabric. Instead, she starts asking a series of follow-up questions ("*how is snow fabric?*" "*do you think ice is fabric?*"), effectively encouraging Jonathan and other students to recognize that snow is actually made of water, a substance that people cannot wear. Only after her students have reached the conclusion that Jonathan's idea is incorrect does Teacher 7 provide a more explicit negative evaluation ("*no, I don't think I would consider water fabric*"). Similarly, when her student Payton proposes that his fabric could be used as material for making shoes, Teacher 7 refrains from providing an explicit negative evaluation, seeking instead to encourage him to evaluate his own idea by asking him follow-up questions ("*would it be very good at keeping water out?*" "*would that probably be a good idea?*"). As a result of relinquishing the right to provide explicit negative evaluations and encouraging students to evaluate themselves, Teacher 7 is able to share authority or expertise with her students, thus effectively establishing a more symmetric form of social relationship with them.

Teacher 7 was also able to encourage her students to evaluate themselves by providing them with feedback that would allow them to recognize the appropriateness or correctness of their own ideas (instead of providing with explicit or implicit positive evaluations). Such discursive practice was employed while students were proposing possible uses for their fabrics:

Jason: This is soft enough to be a jacket.
Teacher 7: This, this fabric is very interesting, it's called a rip-stop, it won't rip, see those little lines in it? It's called a rip-stop, so it won't, it'll keep it from ripping, so it COULD be a good jacket. <u>Do you think, it kinda feels like, would you think water might go through it? Or, do you think it might repel off of it?</u>
Jason: Repel off.
Teacher 7: <u>So, would it be kind of a good water jacket?</u>
Jason: Yeah! THIS WOULD BE KIND OF A NICE WATER JACKET! ((to other students))

When her student Jason proposes that his fabric could be possibly be used to make a jacket, Teacher 7 reacts by providing him with feedback, pointing out that the lines in his fabric sample are called "*rip-stop*." Such information is provided to encourage Jason to recognize that his fabric has weatherproof qualities that would allow it to be used to make as a water jacket. In other words, Teacher 7 provides Jason with feedback in order to encourage him to evaluate himself as being correct. By encouraging her students to take on an evaluative interactional role, Teacher 7 is able to foster a symmetric social structure in her classroom.

The above discursive strategies are directly connected to Teacher 7's participation in the third day of SMIT'N summer institute. As pointed out in Chapter 4, on that particular day, participating teachers identified provision of feedback that can encourage students to evaluate themselves as an essential discursive strategy for teachers to adopt in order to position themselves as guides while interacting with their students. It is precisely such a view of guided inquiry that Teacher 7 implemented in her classroom subsequent to the institute. This student-centered discursive practice is in sharp contrast to Teacher 7's pre-institute authoritative questioning approach, which was focused primarily on student recall of scientific words.

Another discursive strategy adopted by Teacher 7 in order to reduce her authoritative social status was to avoid using *I/you* contrastive pairs that could distance and separate herself interactionally from the students. For instance, while eliciting her students' prior knowledge, Teacher 7 uttered the following question "*can you tell me*, *umm*, *what is fabric?*" As can be seen, Teacher 7 starts her question with "*can you tell me*," cuts herself off, utters the non-verbal token "*umm*," and then repairs her turn in progress by asking the question "*what is fabric?*" As a result of such rapid repair, Teacher 7 is able to avoid asking a question with an "*I/you*" contrastive pair, posing instead a more generalized query about fabrics that contains no personal pronouns. Overall, Teacher 7 continued her pre-institute discursive preference for the distancing personal pronoun "*you*" (high number of *you*-questions), rarely employing the solidarity-building pronoun "*we*" while posing questions to her students.

While facilitating the whole-class discussion, Teacher 7 sometimes resorted to poetic language, a discursive strategy that she had not utilized prior to participating in the SMIT'N institute. For instance, some of Teacher 7's directives contained figures of speech, including a metonymy ("*Travis you need to be on your pockets*" instead of "*Travis, sit down*") and a synecdoche ("*Kindergarten, can I have your eyes and ears?*" instead of "*can you pay attention?*"). By employing such poetic language while giving directives to her students, not only did Teacher 7 avoid taking on an excessively authoritative interactional role, but she also fostered student involvement or engagement. Similarly, Teacher 7 resorted to alliteration (repetitions of similar sounds) while encouraging students to share their observations:

Teacher 7: ((the fabric)) It's shinny like Hanna's football Jersey. What about if girls wanna get dressed up?
Jordan: A skirt.
Teacher 7: It could be a very nice shimmery, shiny skirt, couldn't it?

As underscored above, Teacher 7 reacts to Jordan's idea that his shiny fabric can possibly be used for making a skirt by uttering a series of words with "S" sounds ("shimmery, shiny skirt"). Teacher 7's sound repetitions are primarily aimed at creating student involvement or engagement in the discussion by strategically resorting to amusing linguistic forms. Interestingly, Teacher 7's employment of poetics seems inconsistent with the interactional views she had expressed while participating in the SMIT'N summer institute. As pointed out in Chapter 4, Teacher7 as well as the other two kindergarten teachers argued that younger students might have difficulty understanding some figures of speech such as metonymies, arguing in their reflective reports that "*poetic talk does not really belong in a kindergarten classroom*." However, Teacher 7's effective employment of poetic language in her classroom provides evidence that such discursive strategy can, at least in some instances, be appropriate for lower grade levels.

Teacher 7's use of personal pronouns while giving directions to students remained largely unaffected by her participation in the SMIT'N summer institute. For the most part, she continued to employ distancing and authoritative "*I/you*" pairs while giving whole-class directives. For example, while explaining to students that they would be examining fabric samples in pairs, Teacher 7 gave the following directives "*I have several types of different fabrics. I'm not gonna tell you what this type of fabric it is. I'm gonna, I'm going to put you with partners, I'm gonna pick your partners, so don't even look at anybody… I want you to think about how it could be used for, all the fabrics are different, so it's gonna be different things, okay? So, I want you to think how you could use this fabric.*" Likewise, Teacher 7 continued to employ the solidarity-building pronoun "*we*" while giving directives to individual students. Teacher 7 used this less authoritative and distant directive behavior mostly while asking particular students to share their observations. Example of such directives included "*Jenna, describe your fabric to* <u>*us*</u>*,*" "*Hanna and Jason, describe your fabric to* <u>*us*</u>*, tell* <u>*us*</u> *like is it soft, is it hard, stiff?*" "*Jason, describe your fabric to* <u>*us*</u>*,*" and "*Liz, describe your fabric to* <u>*us*</u>." Overall, Teacher 7 was able to balance these two distinct directive behaviors, positioning herself as the person in control of the classroom without sounding excessively authoritarian.

Another pre-institute directive behavior that remained unaffected by Teacher 7's participation in SMIT'N was her tendency to employ linguistic politeness and indirectness in order to avoid positioning herself authoritatively in relation to students. For instance, when her student Jordan kept interrupting her, Teacher 7 first uttered an interrogative ("*Jordan, are you listening?*") and then an imperative in the form of a verbal ellipsis ("*Jordan*."). Similarly, when her student Kate failed to comply with her request to sit on the floor, Teacher 7 first resorted to a declarative statement ("*Kate, I need you to get on the floor like everybody else*") and then an imperative prefaced with a politeness marker ("<u>*Please*</u>*, put the chair away*"). In both cases, Teacher 7 first resorts to linguistically polite and indirect commands in order to discontinue student misbehavior. However, if unsuccessful, Teacher 7 gradually increases the degree of imposingness of commands, typically shifting from declaratives or interrogatives to imperative statements. Another polite directive behavior that Teacher 7 continued to use after SMIT'N was positive reinforcement. For example, while trying to get student pairs to sit in circle in order to share their observations and inferences, Teacher 7 gave the following directives: "*OKAY, I NEED YOU PLEASE TO COME BACK TO THE CIRCLE (4.0)* <u>*Oh, I like the way Kylie and Nicholas are sitting, thank you, they are following directions, they are sitting quietly*</u>." As indicated, when some students fail to comply with her request, Teacher 7 begins to draw attention to compliant students, strategically keeping student misbehavior in the background.

Summary

The above comparative discourse analysis reveals that Teacher 7 adopted different discursive strategies while implementing pre- and post-institute inquiry science lessons. Prior to SMIT'N, Teacher 7 tended to adopt authoritative discursive strategies, positioning herself asymmetrically and interactionally distant from her students. While facilitating the pre-institute whole-class discussion, Teacher 7 tended to employ authoritative discursive practices such as asking display questions, providing explicit evaluations (both positive and negative), following IRE interactional patterns, adopting a questioning approach focused primarily on student recall of scientific terms, employing questioning techniques such as verbal cloze and cued elicitation, using "*I/you*" contrastive pairs while questioning students, and ignoring topics introduced by some students. In sharp contrast, subsequent to her participation in SMIT'N, Teacher 7 facilitated a whole-class discussion with a more symmetric and closer social structure, frequently adopting less authoritative interactional strategies such as asking sincere questions (truly interested intonation), avoiding explicit oral evaluations, providing implicit positive evaluations (verbatim repetitions with falling intonation), providing implicit negative evaluations (verbatim repetitions with rising intonations followed by challenging questions), blurring the inflectional demarcation of her implicit evaluations, adopting a student-centered questioning approach focused on encouraging students to evaluate themselves (by posing challenging questions and providing informative feedback), and avoiding the use of "*I/you*" contrastive pairs while posing questions. Another change in Teacher 7's inquiry-based discourse was her employment of poetic or involvement-focused language subsequent to the SMIT'N institute. Although interpretable as a mere consequence of contextual differences between pre- and post-institute lessons (e.g., different investigative topics and students), another interpretative possibility is that participation in SMIT'N influenced Teacher 7's inquiry-based discourse. The fact that multiple aspects of Teacher 7's inquiry based discourse changed simultaneously in ways that were consistent with the interactional views she expressed during the summer institute supports the latter interpretation.

Despite all of the above changes, other aspects of Teacher 7's discourse remained unaffected by her participation in the institute. For instance, Teacher 7 continued to show a preference for the distancing personal pronoun "*you*" (high number of you-questions), rarely employing the solidarity-building pronominal form "*we*" while posing questions. Likewise, Teacher 7's directive behavior was virtually the same before and after the institute. While directing students, Teacher 7 tended to give a high number of polite and indirect commands with first-person pronouns ("*we*" when addressing individual students, and "*I*" when giving whole-class directives).

Teacher 4's Inquiry-Based Classroom Discourse

Pre- Institute Interactional Strategies

Prior to attending the SMIT'N institute, Teacher 4 was video-recorded while implementing a classroom inquiry on electromagnetism. Her inquiry lesson was based on the FOSS Magnetism and Electricity Module for Grades 3 & 4 (Lawrence Hall of Science, 2005), being divided into two main parts: whole-class discussion and hands-on exploration. During the whole-class discussion, Teacher 4 asked her fourth graders to name different steps of the scientific process such as posing question, hypothesizing, selecting materials, describing procedures, collecting data and drawing conclusions. As the discussion unfolded, Teacher 4 continued to write the investigative steps identified by her students around a hexagon-shaped diagram drawn on the blackboard (see Figure 5.6). After emphasizing that scientific investigations do not invariably follow a fixed and linear sequence of steps, Teacher 4 asked her students to define and provide examples of independent, dependent and controlled variables in scientific experimentation.

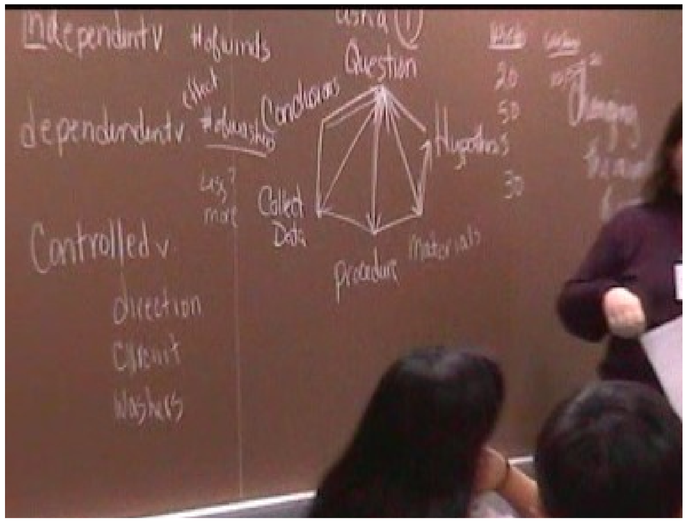

Figure 5.6 – Discussion about the scientific process and experimental variables.

Throughout the whole-class discussion, Teacher 4 tended to adopt discursive strategies that served to establish an asymmetric social structure, positioning herself as a knowledgeable authority and her students as novices. For instance, after reminding her students of a previous lesson in which they had learned how to construct an electromagnet by winding an electric wire around a rivet and then connecting into a closed circuit, Teacher 4 asked how they could possibly use the same procedure to investigate the effect of changing the number of winds of wire on the strength of an electromagnet. Her student Bob then replied "*by winding it up and then making one wind less in them… and then see what* [number of washers] *you can pick up… and then unwind it one, and then see how many washers you can pick up*." While asking students to identity experimental variables in the investigation proposed by Bob, Teacher 4 continued to position herself asymmetrically in relation to her students:

Teacher 4: What is Bob gonna change every time?
Student: The number of winds?
Teacher 4: <u>The number of winds</u>. Okay?

Teacher 4: When Bob changes the number of winds around that rivet, how will he, what will happen that shows change? Carl.
Carl: The number of washers he picked up?
Teacher 4: The number of washers will change.

Teacher 4: So, what do you think should stay the same every time? What should stay the same?
Ian: The direction you wind it?
Teacher 4: The direction that you wind it. Okay?

Teacher 4: What else should he keep the same?
Student: the:: circuit?
Teacher 4: the circuit should stay the same, so don't have the circuit going in this direction, and then change the circuit for the second round, so keep the circuit the same.

As shown in the above excerpts, interactions between Teacher 4 and her students follow an IRE turn taking pattern. Teacher 4 initiates each sequence by asking a display question (e.g., *what is Bob gonna change every time?*), that is, a query whose answer she already knows and that is asked simply to allow students to display or demonstrate their understandings of experimental variables. Sensing that they are being tested, students invariably provide short responses with rising intonations ("*the number of winds?*", "*the number of washers he picked up?*", "*the direction you wind it?*", "*the:: circuit*?"). By making their responses sound like questions, students continue to hedge, that is, avoid committing themselves to their own utterances, at same time positioning themselves as novices who are uncertain about the correctness of their responses and Teacher 4 as an authority who is in a better position to know the right answers. Furthermore, Teacher 4 ends all of the above sequences by repeating students' responses verbatim (rather than providing a more explicit evaluation such as "*you are right*"). Such repetitions serve an implicit evaluative or endorsing purpose, that is, by repeating their responses, Teacher 4 signals to her students that the answers they just provided are correct.

Although Teacher 4 conveyed affirmative evaluations implicitly through verbatim repetitions of students' responses, she tended to adopt a more evasive discursive strategy when her students failed to provide the answer she was looking for. Such evasive reactive behavior was observed during a discussion about the scientific process:

> Teacher 4: First you ask a question and then we said before you even, before I say a word, you already started to do something, and what is that? ((students raise hands)) Nate.
> Nate: Procedure?
> Teacher4: <u>Umm, did you get the materials and everything ready since we asked the question? What did you do in your head,</u> Lee?
> Lee: Hypothesis?
> Teacher 4: You made a hypothesis, didn't you?

Teacher 4 initiates the above discussion by proposing in a very vague manner that the act of posing a research question triggers another cognitive process which students are asked to identify. When her student Nate replies "procedure," Teacher 4 simply says "umm" and immediately initiates a new sequence by rewording her question. Rather than providing an explicit negative evaluation, Teacher 4 skips the evaluative move altogether, an evasive strategy that leads to the occurrence of an I-R couplet. In sharp contrast, when her student Lee offers the response "hypothesis," Teacher 4 provides a positive evaluation by repeating his response verbatim, thus resulting in an IRE sequence. It must also be noticed that both Nate and Lee's responses have a rising intonation, thus suggesting that an asymmetric social structure persists in the classroom even though Teacher 4 has partially relinquished her evaluative interactional rights. Teacher 4's differential reactive behavior to students' responses persisted throughout the whole-class discussion.

Teacher 4 tended to adopt a questioning approach focused mainly on prompting her students to recall particular science words rather than encouraging them to articulate and develop their understandings of science. For instance, while talking about experimental variables, Teacher 4 adopted a line of questioning in which she sought to help her students remember the meaning of the term “independent variable”:

> Teacher 4: We talked about variables last time. Do you remember which one was the independent variable? I gave you a, uhh, memory device, I gave you a memory device. <u>It begins with this</u> ((underlines “in” on the board)) Nate.
> Nate: Inquiry?
> Teacher 4: Oh, that’s a good guess, it begins with IN, the same as inquiry. What are all of you? <u>In::</u>? ((students raise hands)).
> Student: Independent.
> Teacher 4: ((points index finger to another student))
> Student: Inventors?
> Teacher 4: That’s a good one. Investigators, okay? So, what, the variables that investigators change is called the independent variable.

After reminding students that they learned about experimental variables in a previous science lesson, Teacher 4 asks them to define the term “independent variable,” and immediately starts providing verbal cues such as underling the prefix “in” on the board and orally offering a verbal cloze “*In.::?*” In response, her students start calling out science-related words such as “<u>in</u>quiry”, “<u>in</u>dependent”, and “<u>in</u>ventors.” As a result, teacher-student interactions start to resemble a guessing game, a discursive pattern previously described as “cued elicitation” (Edwards & Mercer, 1987). Despite her verbal cues, students are unable to guess the word being sought by Teacher 4 who then decides to just go ahead and say it aloud “investigators.” It must be noticed that Teacher 4 resorts to poetic language, more specific an alliteration in which the sound “in” is repeated twice (“*<u>in</u>vestigators change the <u>in</u>dependent variable*”), as an strategy to help her students recall the meaning of the term independent variable. However, the fact that her students are unable to remember such alliteration suggests that Teacher 4’s previous use of poetic language was ineffective.

Teacher 4’s use of poetic language was limited, leading to a relatively low level of student involvement or engagement during the whole-class discussion. For instance, Teacher 4 resorted to figures of speech only in two different occasions. First, while encouraging her students to recognize that the magnetic force of an electromagnet may be directly proportional to the number of winds of wire around its core, Teacher 4 asks them to predict how many washers they would be able to pick up with twenty winds of wire. In response, her students start providing numbers such as ten, fifteen, and twenty five washers. Then, Teacher 4 says "*twenty five, I heard. Are these logical answers? Would it make sense to say <u>ten thousand</u>?*" to which students reply in chorus "*NO*." As can be seen, Teacher 4 resorts to an exaggeration in order to emphasize to her students that their predictions were not simply random guesses, but reasonable numbers that were based upon previous experiences. In a second occasion, while talking about the scientific process, Teacher 4 uttered "*after you collected your data, <u>eyes on me</u>, then you, we talked about it, to be able to do what?*" Noticing that several of her students were disengaged from the discussion, Teacher 4 uses a synecdoche ("*eyes on me*") as a directive. Such a poetic imperative has a lower impositional value in comparison to more a direct command such as "pay attention," therefore serving a save-facing or politeness function. In other words, Teacher 4 resorts to a poetic directive in order to avoid sounding authoritarian and at the same time foster student involvement. Nonetheless, the level of student involvement in the discussion remained low as evidenced by the fact that only a few students volunteered to make oral contributions while several others continued to walk in and out of the classroom.

Teacher 4 also made use of parallel repetitions in two distinct instances. First, at the beginning of the discussion about the scientific process, Teacher 4 uttered the following directive "*Raise your <u>hands</u>. Uhh, I like <u>the hands, the hands, hands, hands,</u> think about it.*" While trying to get her students to raise their hands before calling out answers, Teacher 4 first utters the imperative "raise your hands" and then immediately follows it with a series of parallel repetitions of the word "hand." Her poetic directive strategy serves multiple interactional functions. First, Teacher 4's parallel repetitions serve to lower the impositional value of her imperative, a politeness device that allows her to avoid sounding excessively authoritarian whiling giving directives. Second, her repetitions of the word "hand" also seem to be an attempt to be amusing, a strategy aimed at fostering student involvement in the discussion. And, third, Teacher 4's parallel repetitions also serve to slow down her students and encourage them to reflect carefully about her question before attempting to get a hold of the discussion floor, thus serving a classroom management function. Teacher 4 also resorted to parallel repetitions while emphasizing to her students that the direction in which the electric wire is wound is an important controlled variable when constructing an electromagnet: "*the direction that you wind it* [the wire]*… if Bob is winding this way, <u>over the top, over the top, over the top</u>* [moving one hand clockwise around the other], *he does it the first time <u>over the top</u>, then the second time he does it <u>under the back, under the back</u>* [moving hand counterclockwise], *is that a logical experiment? Is that consistent? No. He needs to make the way he winds it the same, the direction*." Rather than simply telling students that the wire needs to be wound in the same direction every time, Teacher 4 resorts to contrastive parallel repetitions ("*over the top*/*under the back*") as well as a rhetorical question ("*Is that consistent? No*"), fostering student involvement while enacting what she considers to be an inconsistent investigative approach.

Teacher 4 also made little use of hedges while reacting to students' contributions to the whole-class discussion, opting instead for either verbatim repetitions or negative evaluative moves. The only exception occurred when Teacher 4 asked her students to identify the minimum number of winds that they would have to make in order to construct an electromagnet capable of picking up washers:

Teacher 4: How many winds does it take to pick up washers? Does anybody know?
Student: Twenty?
Student: A lot.
Teacher 4: <u>Maybe</u> twenty, okay. So, if you have twenty winds, how many washers <u>do you think</u> you <u>might</u> pick up?
Student: Ten.
Teacher 4: <u>Hopefully</u> is more than zero, <u>hopefully</u> we're doing it right and getting more than zero.

Teacher 4 starts off the above excerpt by asking the question "*how many winds does it take to pick up washers*?" It must be noticed that Teacher 4 makes no explicit reference to the previous classroom investigation in which her students learned how to construct an electromagnet, instead leaving that reference implicit. Neither does she frame her request explicitly as a tentative prediction or an experimental estimation. As a result, Teacher 4's query starts to resemble a display question, that is, a request aimed testing her students' knowledge of the "right" answer. Such question encourages her students to hedge in order to avoid committing themselves to their predictions. The first student provides a specific number with a rising intonation ("*twenty?*") while the second one makes a characteristically vague estimation ("*a lot*"). Teacher 4 then reacts by prefacing her next move with the uncertainty adverb "*maybe,*" repeating the more specific student response "*twenty*," and then uttering the neutral reactive token "*okay*." As a result, Teacher 4 commits herself to "twenty" being a reasonable response but not necessarily the right answer (i.e., similar numbers of winds might also work). Next, Teacher 4 asks the follow up question "*so, if you have twenty winds, how many washers <u>do you think</u> you <u>might</u> pick up*?" Not only does Teacher 4 asks a *you*-question but she also employs the modal verbal "*might*," thus encouraging her students to provide uncertain or tentative responses (as opposed to the right answer). Toward the end, when a student replies "*ten*," Teacher 4 simply replies "*<u>hopefully</u> is more than zero, <u>hopefully</u> we're doing it right and getting more than zero*." Instead of a verbatim repetition, Teacher 4 provides commentary on the possible meaning of zero washers (a Feedback move). Unlike most other instances, Teacher 4's failure to provide a verbatim repetition does not suggest an implicit negative evaluation of the student's response, a direct consequence of her continued discursive emphasis on tentativeness and uncertainty.

While facilitating the whole-class discussion, Teacher 4 strongly emphasized the creation of solidarity with her students by repeatedly employing the inclusive form of the personal pronoun "we." Her solidarity-building discursive strategy is illustrated in the two excerpts provided below. In the first excerpt, Teacher 4 asks her students about the scientific process, whereas in the second one her questioning focuses on a previous classroom activity in which students learned how to construct electromagnets:

> Teacher 4: So, then <u>we</u> had materials, then you guys were to come up with your own what?
> Student: Procedure?
> Teacher 4: Procedure, okay? Okay? After you did your procedure, you were asked to do one of those nature of science steps. Do you remember what it was?
> Student: Data?
> Teacher 4: Data. You were to collect your data. And <u>we</u> were pretty, uhh, picky about that, weren't <u>we</u>? <u>We</u> used this sheet, used that sheet.

> Teacher 4: What did <u>we</u> learn about, what does winding have to do with electromagnets? What does winds, <u>we</u>'re talking about, are <u>we</u> talking about the winds ((as in breeze))? What are <u>we</u> talking about the WINDS ((as in coil))? How did <u>we</u> make an electromagnet last time?

As can be seen above, Teacher 4's seeks to create solidarity with her students by continuously employing the pronoun "*we*" while referring to past classroom activities ("*we had materials*", "we *were pretty picky about that*", "*we used this sheet"*) and by frequently asking *we* questions ("*what are we talking about*?", "*how did we make an electromagnet?*"). By doing so, Teacher 4 attempts to foster an atmosphere of social closeness in the classroom, that is, the impression that she and her students share similar social statuses and belong to a common social group rather than two (i.e., authority and novice). In sharp contrast, Teacher 4's verbatim repetitions of students' responses seem to have the exact opposite interactional effect, increasing the social distance between the teacher and her students. Even though, disguised as neutral acknowledgment, Teacher 4's affirmative evaluations continue to reinforce her authoritative interactional status. As evidenced by the rising intonation of students' responses ("*procedure?*", "*data?*"), an asymmetric social structure persists in the classroom despite Teacher 4's solidarity-building discursive strategy.

After bringing the whole-class discussion into a closure, Teacher 4 provided her students with a collection of materials (circuit bases, D-cell alkaline batteries, cell holders, switches, electric wires, washers, etc.) and then instructed them to design and implement an investigation to determine the relationship between number of winds of wire around a rivet and the strength of the resulting electromagnetic force. Working in small groups, students constructed electromagnets and measured their magnetic strengths by counting the number of washers they were able to pick up (Figure 5.7). Teacher 4 also provided students with a worksheet on which to write research questions, list materials, describe procedures and draw a line graph (number of winds versus number of washers lifted).

Figure 5.7 – Student group assembling an electromagnet.

Teacher 4's use of personal pronouns changed drastically while interacting with small groups of students. Rather than continuing to resort to the solidarity-building "we," Teacher 4 tended to use "I/you" contrastive pairs, hence distancing herself socially from student groups and foregrounding her authority as the main driving force behind their classroom inquiries. For instance, Teacher 4 adopted this distancing interactional pattern while assisting a group of three students who was able to construct a functional electromagnet but was unsure about what procedure to adopt in order to investigate the effect of winds of wire on the number of washers picked up:

> Teacher 4: How are you gonna show me how many washers it can pick up? (2.0) How are you gonna show me? (2.0) How will you show me how many wires it's gonna pick up? How many washers. (2.0) Put it in the middle of the table. How will you show me? Which end are you picking up with?
>
> Student: This one.
>
> Teacher 4: Okay. So, put it right in the middle of that pile. Transport them over here. So, you have to be able to do it in one pull, okay? You have to be able to do it in one pull. Okay, why don't we try, why don't you try unwinding it ? And wrap it real close up here, start with twenty and work your way up again. Start again. Well, maybe you should try this one battery instead of two. It's really whatever you ((she walks away))

Teacher 4 starts off the above discussion by repeatedly asking the group of students to propose a possible procedure for their investigation ("how are you gonna show me?"). Getting no response from the students, Teacher 4 repeats her question four times. By continuously using "I/you" contrastive pairs, Teacher 4 creates a clear social demarcation between herself and the students, implicitly portraying the students' inquiry efforts as an attempt to please her (the authority who will be grading their reports) rather than an investigation being conducted in order to reveal the effect of winds on the strength of an electromagnet. While foregrounding her authoritative role, Teacher 4 seems to encourage the students to view their ongoing inquiry as just another classroom assignment that will be subjected to her grading instead of an actual investigative endeavor. As a result, interactions between Teacher 4 and the student group becomes mostly focused on clarifying her expectations for the classroom assignment.

As underlined above, the previous excerpt also provides some insight into Teacher 4's directive behavior. Faced with the students' unwillingness or inability to provide an answer to her procedural question, Teacher 4 decides to go ahead and provide them with an investigative procedure. Overall, Teacher 4 gives a series of eleven directives: seven imperatives (e.g., "*put it right in the middle of that pile*"), three declaratives (e.g., *"you have to be able to do it in one pull*"), and one interrogative ("*why don't you try unwinding it?*"). Furthermore, it should be noticed that Teacher 4 only resorts to negative politeness formula twice ("*maybe*", "*it's really whatever you*"). This apparent predominance of imperatives and direct directives suggests that Teacher 4 is commanding rather than merely suggesting to students how to proceed with their investigation. Teacher 4 also uses the second person pronoun "*you*" five times, thus maintaining a distant interactional alignment in relation to her students. The inclusive pronoun "*we*" is employed once but is quickly replaced for the more distant "*you*" ("*why don't <u>we</u> try, why don't <u>you</u> try winding it?*"). Finally, it should be noted that Teacher 4 only gives physical directives (i.e., requests for the performance of physical acts), thus focusing her commands exclusively on the performance of experimental procedures rather than student cognition or understanding.

A few minutes later, Teacher 4 walks by the above student group for a second time. When she observes that the three students were not following the procedure previously described by her, she immediately utters the following directive "*Uh, uh, uh, uh. Just put it right into the middle of the pile and see how many it pulls up*." Despite the minimizer "just," Teacher 4's imperative statement leaves little doubt that her previous directives were more than mere suggestions, they were in fact commands that she expected students to follow. In other words, Teacher 4 interspersed her previous imperatives with polite or indirect linguistic formulae to lower the imposing value of her directives and to avoid appearing authoritarian, not to actually give students the option of simply disregarding her instructions.

Teacher 4 continued to adopt similar discursive strategies while interacting with a second student group. For example, a few minutes later, a second group of students requested Teacher 4 to assist them with their investigative procedure, leading to the recurrence of most of the previously described teacher-student interactional patterns:

> Teacher 4: So, how are you going to show me that it can attract that many washers, can attract washers?
> Student: Like, uhh, umm, count it=
> Student 2: Try it a couple of times and then count it.
> Teacher 4: Okay.
> Student 2: To see what, where it will pick up the most.
> Teacher 4: Where would you place them while you are counting them?
> Student 2: Over, uhh, in this spot.
> Teacher 4: Sure. So, you could try, you know, each person could try it with the same number, you know, the more times you repeat something, the better your chances are of having, you know, of understanding the correct answer, so you would start your energy source, you would find a way, no, I would put them right into the middle of a pile, right? Does that make sense? You can get a bunch. And then, now you see, you've gotta be able to carry it over there. Do you see what I mean? So, can you adjust your wire so that you can carry washers over to here, drop them, and then count them? Do it a couple or three times. Does that make sense? Is that repeatable? Okay. So, you're gonna have to adjust your wire a little bit, so you've got the room to move it.

Teacher 4 begins by repeating the same procedural question she asked the first group "*how are you going to show me that it* [the electromagnet] *can attract washers?*" However, this group of students does provide her with responses, clearly describing the investigative procedures they intend to adopt ("*try it a couple of times and then count it*", "[put it] *over in this spot*"). Each time, Teacher 4 reacts by providing relatively neutral comments such as "okay" and "sure," thus implicitly signaling to students that the procedural steps being proposed by them are indeed reasonable. After that, Teacher 4 provides a series of seven physical directives: five declaratives (e.g., "*each person could try it with the same number*"), one imperative ("*do it a* *couple or 3 times*"), and one interrogative ("*can you adjust your wire so that you can carry washers over to here, drop them, and then count them*?"). As can be noticed, most of Teacher 4's directives, more specifically four out of seven, contain polite formulae with modal verbs (*can, could, would*) while only one imperative is issued. Her stronger emphasis on politeness (in comparison to her interactions with the previous group) is related to the fact that this particular group of students already seems to have a pretty good idea about how to proceed with their investigation, thus allowing Teacher 4 to be relatively more "suggestive" or indirect in her instructions to them.

Teacher 4 sometimes interrupted the student groups' investigations in order to provide them with whole-class directives. Her usual approach was to turn off the lights and then request the students' attention by uttering polite directives such as "*if I could have your attention for one second, please*" and "*I need your attention, please.*" While instructing her students, Teacher 4 sometimes used involved or poetic language, a discursive strategy that she had also used while facilitating the whole-class discussion. Overall, Teacher 4 gave four poetic directives which are listed below:

> Teacher 4: On the back you can write the materials you, please listen, <u>eyes on me</u> please.

> Teacher 4: Now, on your graph, you will see that <u>the x-axis at the bottom wants to know</u> the number of winds, and the y-axis along the side is the number of washers lifted.

> Teacher 4: If you're in a group where somebody, you cannot get it to work, would you go, quietly go to somebody's who is working? Raise your hands if yours is working. So, these five groups' I know are working. If your group's is not working, <u>would you fishbowl?</u> That means you're not, you are just watching what they are doing, okay? So, <u>come in fishbowl</u> in one of these five groups.

> Teacher 4: In fifteen minutes, <u>the bell will be calling</u> for buses.

As indicated above, Teacher 4 uses poetic language while giving directives to students in four different occasions. More specifically, Teacher 4 makes use of different figures of speech: a synecdoche ("*eyes on me*"), two personifications ("*the x-axis at the bottom wants to know*" and "*the bell will be calling for buses*") and a metaphor ("*to fishbowl*"). As previously argued, Teacher 4's poetic or figurative directives are discursively multifunctional, serving both as a strategy to avoid projecting an authoritarian image as well as an attempt to foster student involvement or engagement.

In contrast, Teacher 4 tended to resort exclusively to imperatives while giving directives to students who misbehaved or failed to comply with her previous requests. Such directive behavior is illustrated in the two excerpts provided below. In the first one, Teacher 4's interactions with a small group of students are abruptly interrupted by a student from a different group who comes up to her to make a complaint, whereas the directive in the second excerpt is given to a student who is standing up rather than conducting the investigation requested by Teacher 4:

> Teacher 4: What's a procedure=
> Student: Mary, keeps throwing her eraser at us.
> Teacher 4: <u>Please sit down, honey</u>.
> Student: Mary, keeps throwing her eraser at us.
> Teacher 4: Okay, I will take care of it, <u>sit down</u>.
>
> Teacher 4: Are you still waiting for me to check your light? Oh, I did already. <u>Sit down, please and get busy</u>.

When approached by the first student, Teacher 4 simply replies with the directive "*please sit down, honey*." As can be seen, Teacher 4 resorts to an imperative statement prefaced with the politeness marker "*please*" and followed by the personal and informal treatment form "*honey*." As a result, her directive is softened from a demand to a polite request. However, rather than complying, the student simply repeats his complaint ("*Mary, keeps throwing her eraser at us*").

In response, Teacher 4 acknowledges receiving his complaint, and then repeats her previous imperative ("*sit down*") without any politeness softeners. As can be seen, Teacher 4's discursive strategy to deal with student misbehavior is to continue to issue imperatives that are increasingly less polite, thus gradually transitioning from requests to demands for compliance. Similarly, the student who is standing receives the polite imperative statement "*sit down, please and get busy*." However, the student's immediate compliance prevents Teacher 4 from making a less polite demand.

Post-Institute Interactional Strategies

Subsequent to her participation in the SMIT'N summer institute, Teacher 4 implemented an inquiry-based classroom investigation entitled "*Meet the Crayfish*". Part of the FOSS Structures of Life Module for Grades 3 and 4 (Lawrence Hall of Science, 2005), this particular science curriculum encourages students to investigate and familiarize themselves with crayfish biological structures, behaviors and environments. Students are provided with live crayfish, basins covered with rocks and some water, small plastic shelters, etc. and are then asked to conduct research on crayfish biological structures and behaviors, including their feeding and aggressive habits. Teacher 4's investigative lesson started with a whole-class discussion about crayfish behaviors followed by guided small-group planning (posing research question and designing procedure for behavioral experiment), guided small-group implementation (observing crayfish behaviors), and whole-class sharing of results (student presentation of findings).

During the whole-class discussion, Teacher 4 and her fourth-grade students talked about the meaning of scientific inquiry as well as science process skills such as observing, predicting, hypothesizing, and question posing. Teacher 4 also asked her students to observe the behavior of *Rocky the singing lobster*, an electronic crustacean model manufactured by Gemmy Industries that dances, shakes its claws and tail, and moves its lips while singing the tunes "*Rock the Boat*" and "*Sea Cruise*." After observing Rocky's performance (Figure 5.8), students were asked to make behavioral comparisons between the electronic shellfish model and live crayfish specimens that Teacher 4 had brought into the classroom a few days earlier.

Figure 5.8 – Teacher 4 showing Rocky the singing lobster to fourth graders.

While facilitating the whole-class discussion, Teacher 4 tended to adopt less authoritative interactional strategies than she did during the pre-institute discussion about electromagnets, hence demonstrating an ability to position herself more symmetrically in relation to her students. Teacher 4 was able to avoid acquiring the interactional status of a knowledgeable authority through several linguistic means. For instance, Teacher 4 stopped repeating all of her students' ideas and responses verbatim, choosing instead to provide reactive tokens and backchannels that effectively encouraged students to elaborate on their own ideas and to evaluate each other. These discursive strategies are illustrated in the two excerpts provided below:

Teacher 4: What kind of animals are they [crayfish]? Go ahead Olivia.
Olivia: They are crustaceans.
Teacher 4: <u>Uhuh</u>.
Olivia: And they're, they are crustaceans and arachnids.
Student: <u>They ARE arachnids, they have eight legs</u>.

Teacher 4: Why <u>would</u> they [crayfish] go into a special place after they molted?
India: Well, I was gonna say to grow a new shell, they can go into, umm, some shelter because without the shell they are protected by something.
Teacher 4: <u>Good, very good</u>.
India: And also, umm, they eat their shells for calcium.

Teacher 4: Excellent two points.

Teacher 4 starts off the first excerpt by asking a display question, prompting her student Olivia to reply the right response "*crustaceans*." However, instead of repeating the student's response verbatim or providing a more explicit positive evaluation, Teacher 4 reacts by uttering the nonverbal token "uhuh," thus displaying minimal listenership or recipient behavior. More importantly, Teacher 4's reactive token serves as a backchannel, encouraging Olivia to elaborate her biological classification ("*crustaceans and arachnids*") and a second student to evaluate her classification as being scientifically correct ("*they are arachnids, they have eight legs*"). Likewise in the second excerpt, when India proposes that crayfish look for shelter in order to protect themselves from predators after molting, Teacher 4 reacts by uttering "*good, very good*." India then goes on to propose yet another explanation ("*they eat their shells for calcium*"). The fact that India provides a second response (rather than waiting for the teacher to make another initiative move) suggests that Teacher 4's evaluative comment "*good, very good*" serve as a form of backchannel instead of a closing evaluation, effectively maintaining an open channel of communication between Teacher 4 and her student. India's second response is also likely to be related to the fact that Teacher 4 employs a hedge (the modal verb *would*) in her initial move, thus marking her question as a request for possible and tentative explanations rather than the right answer.

Teacher 4's avoidance of verbatim repetitions of students' responses is directly connected to her participation in the SMIT'N summer institute. As pointed out in Chapter 4, participating teachers discussed the interactional implications of continuously repeating students' responses, arguing that such practice could potentially inhibit student-student verbal communication. Teacher 4 held this negative view of verbatim repetitions subsequent to SMIT'N. Not only did

Teacher 4 stop repeating all of her students' contributions but she also explicitly directed them to listen to each other: "*I hope we are listening to each other, listen to each other, Andy, I want you to listen to each other, okay?*"

Teacher 4 also tended to react differently to students' failed attempts at providing her with the responses she was after. Instead of evading evaluative moves (her pre-institute strategy) or providing explicit negative evaluations, Teacher 4 often resorted to hedges. This discursive tendency was observed early in the discussion when she asked the open-ended question "*what does it mean to inquire about something*?" This question led to interactions dominated by hedges:

> Spencer: <u>I think</u>, <u>I guess</u>, uhh, it <u>almost</u> <u>sounds like</u> something mandatory like you have to do it.
> Teacher 4: <u>You have to do it?</u> Uhh, <u>I could see it from the inside</u> like mandatory, you have to do it, okay, <u>we will talk about that later</u>. Have to do it ((writes on the black board)). Okay, I <u>kinda</u> like that actually, it's not.
> Spencer: Uhuh
> Teacher 4: I mean, you're <u>almost</u>, <u>you're over there</u>.

As indicated above, her student Spencer prefaces his attempted response with two plausibility shields ("*I think*", "*I guess*"), a hesitation discourse marker "*uhh,*" and the vague expression ("*it almost sounds like*"). As a result, Spencer is able to avoid fully committing himself to the idea that inquiry is "*something mandatory,*" at the same time attaching doubt to the validity of his response. More importantly, Teacher 4 reacts by providing a verbatim repetition with a rising intonation ("*you have to do it?*"), uttering vague comments ("*I could see it from the inside*"), writing Spencer's idea on the board, and then continuing to provide hedging evaluative comments ("*kinda*", "*almost*"). As a result of persistently hedging and explicitly indicating that Spencer's idea will require further consideration, Teacher 4 ends up providing an implicit negative evaluation. Furthermore, her utterance "*we will talk about that later*" serves to highlight to students that she is simply writing Spencer's response on the board rather than endorsing it as a valid idea. Teacher 4's adoption of such discursive strategies is a direct consequence of her participation in the SMIT'N institute. As pointed out in Chapter 4, participants argued that elementary teachers could transcribe students' misconceptions on the board without officially endorsing it by adding explicit disclosures of tentativeness and then revising it later in the lesson. Furthermore, SMIT'N participants also emphasized that teachers should avoid providing explicit evaluative comments too early in the lesson in order to avoid creating the impression that students' classroom inquiries were too obvious; such practice could potentially discourage students from investigating (Chapter 4). Teacher 4's adoption of such discursive strategies suggests that she has incorporated those ideas into her inquiry-based classroom practices.

Another discursive strategy adopted by Teacher 4 in order to avoid positioning herself as a knowledgeable authority during the classroom inquiry was to explicitly state that she did not know about certain aspects of crayfish behavior and biology. Teacher 4 adopted this discursive strategy three different times during the crayfish classroom inquiry. The first time was during a discussion about crayfish molting behaviors. When a student asked her "*how long does it take for their* [new] *shell to get harder*?" Teacher 4 replied "*very good question, <u>I don't know that one</u>.*" Similarly, after pointing out that the crayfish specimens did not eat the cat food when she tried to feed them, Teacher 4 says "*<u>I don't know why they wouldn't eat it</u>, maybe they don't wanna eat it in captivity or whatever, but that's a good question too. Why didn't they eat it? And what possibly could they eat?*" The third instance occurred after Teacher 4 played the singing lobster for the first time. When Teacher 4 asked her students to share observations they had made, a student unexpectedly replied:

Student: <u>It's thingie</u> ((laughs))
Teacher 4: And, do our crayfish ((smiles and mumbles as if whispering back to the student))?
Students: No ((laughs))
Teacher 4: Alright, here we go ((students start talking)) <u>We don't know that, you know what, we don't know that for sure do we</u>?

In response to Teacher 4's question, the above student employs in a somewhat playful tone the euphemism "*thingie*" to politely refer to what she interprets as being a male sexual organ (a protuberance that became visible underneath the singing lobster when it stood up). Surprised by the unexpected response, Teacher 4 reacts by playfully and indirectly questioning whether crayfish do in fact have male genitalia and then explicitly pointing out that it is a topic unknown to her and the students ("<u>we</u> don't know that, <u>we</u> don't know that for sure do <u>we</u>?"). It must be noticed that, while stating their lack of expertise or authority on the subject of crayfish reproductive organs, Teacher 4 resorts to the inclusive pronominal form "*we*," thus positioning herself symmetrically in relation to her students.

During the whole-class discussion, Teacher 4 tended to ask open-ended questions ("*what behaviors did you notice this masterpiece* [singing lobster] *doing?*", "*what behaviors do you think our crayfish engage in*?") and frequently resorted to pumping ("*what else did you observe*?", "*what else*?", "*something else*?"). Rather than focusing on student recall of particular words and shared classroom experiences (pre-institute discussion), Teacher 4 adopted a questioning approach centered on her students' individual and informal experiences with crayfish. The student-centeredness of the whole-class discussion is illustrated below. In the first excerpt, Diego shares his experiences during a family trip to the state of Michigan, whereas in the second one Olivia talks about her two pets:

Diego: When we were in Michigan, umm, there was this one little dock where there were tons of crayfish, and we would feed them French fries and they would eat that, and they would take it and eat them, but why wouldn't they take the cat food?

Teacher 4: Excellent question. Why do you think? What do you hypothesize? About what, about them eating the French fries and these guys not eating the cat food? What do you think?

Diego: I don't know. The French fries are better ((laughs)).

Teacher 4: Something about the FLAVOR. Maybe there is a different FLAVOR.

Olivia: Umm, I raised these two crayfish, I named them Henry and George ((laughs)) and, umm, we fed them just fish food or, I can't remember, it was a long time ago, we fed them some kind of fish food like, I can't remember if it was like these drier ones or the kind the we feed our fish.

Teacher 4: Sure.

Olivia: But they ate it, and they got really big.

Teacher 4: And they grew and they, they thrived? They didn't die from it?

Olivia: Yeah, and then we let them go.

Teacher 4: Well, this is background information, really excellent.

Several of Teacher 4's prevalent discursive strategies can be identified in the above excerpts. First, Teacher 4 tended to ask *you*-questions, infrequently employing the solidarity-building pronoun "*we*" (predominant during the pre-institute discussion). This apparent shift from first to second personal pronoun is related to the change in discursive focus from shared classroom experiences to individual and informal ones. Second, Teacher 4 often resorted to reflective toss ("*excellent question, why do you think*?") in order to persuade her students to do the thinking and encourage them to take on the interactional role of authorities or experts. Third, Teacher 4 frequently employed backchannels ("*sure*") to encourage students to make longer expert-like contributions. And fourth, Teacher 4 often utilized hedges ("*maybe*") in order to emphasize tentativeness in her contributions to the discussion and to position herself non-authoritatively. Through the combined use such discursive strategies, Teacher 4 was effectively able to foster a significantly more symmetric whole-class discussion than she did prior to the SMIT'N institute. The two above excerpts provide ample evidence of interactional symmetricality including the two students' performance of initiating moves, their provision of longer discursive contributions, their preference for falling intonation as well as their reduced employment of hedges.

Overall, Teacher 4 was able to foster a considerably higher level of student involvement after the SMIT'N institute than she did before. Such instructional achievement was a direct consequence of her increased and more effective employment of involved language throughout the whole-class discussion. For instance, at the beginning of the lesson, Teacher 4 gave her students the following directive "*I want you to set everything aside on your desk, <u>we</u>'re just <u>using our brains today</u> in order to <u>use our hands later in the week</u>, okay?*" and later, before playing the singing lobster, Teacher 4 uttered the following "*<u>we</u>'ve been doing it* [the singing lobster] *kinda for entertainment, haven't <u>we</u>? But today, I want you to <u>look at it</u> <u>with different eyes</u>, okay? I want you to look for a behavior that this crustacean does, okay?*" As indicated above, in both cases Teacher 4 gives directives that combine the solidarity-building personal pronoun "*we*" with poetic linguistic forms such as parallel repetitions ("*<u>using our brains today</u>*… *<u>use our hands later in the week</u>*") and a metonymy ("*look at it with different eyes*"), thus fostering involvement and projecting an interactionally closer and less authoritative self image while directing her students.

Rather than being mostly limited to her directives (pre-institute), Teacher 4 tended to employ involved language throughout the whole-class discussion. Her tendency toward more frequent employment of poetics is illustrated below. The first two excerpts were uttered by Teacher 4 while talking to her students about the meaning of scientific inquiry, whereas the last two were uttered while comparing the singing lobster performance to real crayfish behavior:

> Teacher 4: Today we are going to begin an introduction about inquiry, and people have asked me today *What is this, what is this?* And, what do I keep saying to everybody? <u>Inquiring minds want to know</u>.

Teacher 4: An interrogative sentence inquires. An interrogative sentence inquires ((she smiles)) I will say it again, an interrogative sentence inquires. What do interrogative sentences do? What's the job of those sentences?

Teacher 4: So are we in agreement then that we saw the behaviors of tail flapping, flopping ((starts writing on transparency)) flapping, flipping, and you called it flailing.

Teacher 4: It [crayfish specimen] was just standing there and it would go HUH, HUH, HUH, huh, huh ((enacting observed crayfish behavior))

As can be seen above, while clarifying the meaning of the verb *to inquire* to her students, Teacher 4 employs the idiomatic expression "*inquiring minds want to know*" (also a metonymy) as well as parallel repetitions of a second metonymy "*an interrogative sentence inquires*." Her employment of such poetic linguistic forms is aimed primarily at making the contents of her utterances more memorable to her students, that is, a discursive strategy that serves primarily to enhance student recall. Likewise, Teacher 4 resorts to an alliteration ("*flapping, flopping, flapping, flipping, flailing*") while referring to the singing lobster's movement of its tail, and to an onomatopoeia while enacting a previously observed crayfish behavior ("*huh, huh, huh, huh, huh*"). These two poetic devices are focused mainly on the creation of student involvement through employment of amusing linguistic forms.

Another involvement-focused discursive strategy frequently employed by Teacher 4 was to ask rhetorical questions. Overall, the frequency of use of such discursive practice was relatively higher in comparison to the pre-institute discussion. For example, while using the behavioral issue raised by her student Diego ("*why crayfish would eat French fries but they wouldn't take cat food?*") as an example to articulate what she considered to be attributes of a good research question, Teacher 4 made the following comments "*his question is an excellent one for THREE reasons, first of all, it's something he really is curious about. Do you wanna answer a question that you think is BORING? I don't care why they do this* ((enacting boredom)) *would you even wanna do research on that? No.*" Soon after that, Teacher 4 also uttered "*DON'T YOU HATE IT when you're asked to figure something out when you know the answer already? I already have the answer to that.*" It can be observed that Teacher 4 poses the two underlined questions and then immediately provides responses to them ("*no*" and "*I already have the answer to that*"). Rather than actual requests aimed at eliciting information from the students, Teacher 4 is asking rhetorical questions, that is, queries aimed at arousing her students' interest and involvement in the discussion. Overall, Teacher 4's was able to make effective of use of involvement-focused discursive strategies, creating and maintaining a high level of student involvement throughout the whole-class discussion.

Once the whole-class discussion came to an end, students formed small groups, collaboratively planned their behavioral inquiries (discussed and recorded their research question, hypothesis, procedure and materials on a worksheet provided by Teacher 4) and then implemented their investigations by carefully placing their crayfish specimens in large plastic basins covered with rocks and a thin layer of water and then making behavioral observations. Students' also placed shelters (small plastic plant pots cut in half) and some algae in their basins to simulate crayfish natural habitat (see Figure 5.9 below).

Figure 5.9 - Fourth graders conducting behavioral research on crayfish specimen.

While interacting with small groups, Teacher 4 tended to position herself symmetrically, taking on the social role of a group member rather than an authority who would later be grading the students' inquiry efforts (her pre-institute interactional positioning). Teacher 4's tendency to favor interactional symmetricality is illustrated in the two excerpts provided below. In the first excerpt, Teacher 4 helps a student group who does not want to investigate crayfish eating habits to come up with a different research topic. In the second excerpt, Teacher 4 interacts with a second group of students who plans to research crayfish eating habits by observing their specimen's response to food commonly found in the wild (minnows) and human-made food (French fries). More specifically, the topic of the second discussion is whether or not to offer French fries covered with ketchup to the crayfish specimen:

> Teacher 4: What are some other things that they do that <u>we</u> could, <u>we</u> could research?
> Student: What the hopping means.
> Teacher 4: What the hopping means. Could <u>we</u>, could <u>we</u> set up a situation where they hop again? <u>We</u> could probably show it again, you know, it was in the food container. I have no idea though if <u>we</u> can, you know.
> Student: Maybe it just, it's not used to a different water, now it doesn't have that water=
>
> Student: Maybe we need ketchup.
> Spencer: I don't think we need ketchup.
> Teacher 4: I'm afraid that it would enter in another variable, because if they, if <u>we</u> put the French fries in ketchup, <u>we</u> would not know, are they eating for the French fry or [are they eating it for the ketchup?
> Spencer: [Yeah, for the ketchup.
> Teacher 4: Right, so <u>our</u> variables <u>we</u> wanna keep real easy so it's kinda clear cut.

As indicated above, Teacher 4 uses the pronoun "*we*" several times while encouraging the first group to come up with a potential research question, clearly creating the impression that she would be taking part in the investigation not as an evaluative authority, but as a supportive group member ("*<u>we</u> could probably show it again*"). Likewise, while pointing out that the use of ketchup would constitute an additional variable that could potentially complicate the second student group's behavioral experiment, Teacher 4 continues to use the plural form of the second-person pronoun ("*if* <u>*we*</u> *put the French fries*," "<u>*our*</u> *variables*"), positioning herself as just another member of the group whose intention is to ensure the adoption of an effective experimental design. As a result, Teacher 4 is able to background her authoritative status and to encourage her students to view their classroom assignment as an authentic inquiry endeavor, that is, a collective and authentic effort to investigate and learn about crayfish behavior rather than just another attempt to meet the expectations of an authoritative teacher who will be evaluating their work.

In addition to avoiding the role of an authoritative evaluator, Teacher 4 also encouraged her students to view their classroom assignment as an authentic scientific inquiry by continuing to emphasize the need for student groups to pose and pursue "sincere" research questions. For example, before allowing Student 3 to join a group that would be investigating whether crayfish had a dietary preference for sugar, Teacher 4 asked him a series of questions to ensure that he would be investigating a "sincere" research question:

Student3: I don't have a partner.
Teacher 4: Is it okay if he, do you wanna, <u>are you curious as to whether crayfish have a sweet tooth or not?</u>
Student 3: ((shakes head affirmatively))
Teacher 4: <u>Are you truly interested in that?</u>
Student 3: ((shakes head affirmatively))
Teacher 4: <u>Do you know the answer?</u>
Student 3: Mm um ((shakes head negatively))
Teacher 4: <u>Do you think you could figure out how to test it?</u>
Student 3: Um hm.
Teacher 4: I think you have a partner here.

When Student 3 points out that he was unable to locate peers interested in forming a group with him (an indirect request for her assistance), Teacher 4 reacts by asking a series of four *you*-questions with a yes/no format. Teacher 4 adopts a line of questioning focused primarily on requesting honest confirmations ("*truly*") from Student 3 with regard to his curiosity or interest in the research question ("*whether crayfish have a sweet tooth or not?*"), knowledgeability of its answer as well as its experimental feasibility. Rather than eliciting new information or testing his scientific understandings, Teacher 4 seeks to ensure that Student 3 will have a sincere or authentic research question to investigate (i.e., an authentic inquiry experience).

Teacher 4's emphasis on the authenticity or sincerity of students' research question is related to her participation in the SMIT'N institute. As pointed out in Chapter 4, the issue of "linguistic sincerity" of questions was discussed extensively on the second day of the summer institute. During this discussion, it was emphasized that in order to be considered genuine, a question needs to meet three sincerity conditions: the person who poses it does not know the answer, would like to know the answer, and has reason to believe that the answer can be obtained (Labov, 1970). Questions that fail to meet such sincerity conditions constitute requests for public displays of knowledge rather than genuine quests for information (Labov & Fanshel, 1977). As illustrated above, subsequent to SMIT'N, Teacher 4 sought to ensure that her students engaged in genuine quests for information (rather than public displays of knowledge) by encouraging them to pose and pursue research questions that met the sincerity conditions discussed during the summer institute.

There were also noticeable changes in Teacher 4's directive behavior. Such changes are illustrated in the excerpt below wherein Teacher 4 continues to interact with the group of three students who is interested in determining whether crayfish have a dietary preference for sugar (idiomatically and poetically put by the students as the metonymy "*having a sweet tooth*"):

> Teacher 4: What is it that <u>we</u> know about crayfish that makes <u>us</u> think that they might have a sweet tooth?
> Student2: Because they like eating, uhh, cat food besides the stuff they are used to eating.
> Teacher 4: Is cat food sweet?
> Student2: Umm, I don't know.

Teacher 4: So, think about what, <u>think about what we know about crayfish</u> and whether you think they're gonna go for the sweeter food or for, umm, the: not so sweeter food, and then just why do you think so. But to say *yes, I think they do* is a hypothesis but is not, <u>I need you to base it on your background information</u>, okay? So, <u>really think and talk about what they eat in nature</u>, and as I know in captivity is the, umm, cat food. I wish I had an ingredients box to see if there is any sugar in cat food, <u>that might be worth researching tonight</u>. Do you guys have cats?

Student: YES

Student2: Umm, four.

Teacher 4: <u>It might be worth looking</u>, umm, <u>go ahead and fill out your hypothesis now</u>=

Student: Can I try some cat food? ((laughs))

Teacher 4: <u>Remember what we said about investigations</u> ((laughs)). Umm, <u>think about it</u>, <u>make your educated guess</u>, and <u>maybe do some research tonight</u> to see if there is any sugar in cat food, and see.

Student: I will just check the back of it.

Student2: We're also gonna bring different kinds of sprinkles, we're gonna buy those little sprinkles that are like little pellets, and some that are a little longer.

Teacher 4: But then you are not really looking at sweet tooth, and it might be easy being able to eat it, you see what, <u>keep your variables EASY</u>, uhh, these are great, this would be very fascinating, but you've got what it is you're testing. Do you see what I mean?

Student2: I think it would be easy for them to pick up the ones, umm, the longer ones.

Teacher 4: <u>You wanna make sure that it's as close as it can be to each</u>, so what you're really testing is the flavor.

Student2: Okay.

As indicated above, Teacher 4 gives a total of twelve directives to her students: eight imperatives (e.g., "*keep your variables easy*") and four declaratives (e.g., "*you wanna make sure that it's as close as it can be to each*"). Furthermore, Teacher 4 resorts to negative politeness devices three times ("*that <u>might</u> be worth researching tonight,*" "*it <u>might</u> be worth looking,*" "*<u>maybe</u> do some research tonight*"), thus maintaining her pre-institute tendency to guide small groups predominantly through imperatives and direct directives. However, unlike prior to the institute (exclusive use of the distancing pronoun "*you*"), Teacher 4 starts to employ the solidarity-building "*we*" while giving directives ("*think about what <u>we</u> know about <u>our</u> crayfish,*" "*remember what we said about investigations*"), thus adopting a relatively closer and less authoritative interactional positioning in relation to small student groups. Another important change in Teacher 4's directive behavior is that she gives commands for a variety of acts, including physical, cognitive and textual directives (Hyland, 2002). Not only does Teacher 4 urge her students to perform research procedures (e.g., "*you wanna make sure that it's as close as it can be to each*") but also to reconsider previously discussed information ("*think about what we know about crayfish*") and to refer to certain parts of their report or text ("*go ahead and fill out your hypothesis now*"). So, instead of focusing exclusively on the students' experimental procedures (pre-institute directive behavior), Teacher 4 also pays close attention to their cognitive and writing activities.

Teacher 4's whole-class directives also changed subsequent to SMIT'N. Rather than relying mainly on polite and poetic whole-class directives (her pre-institute directive behavior), Teacher 4 tended to employ directing strategies discussed extensively on the eighth day of the summer institute, including requests for physical displays of student listenership:

> Teacher 4: OKAY, <u>if you can hear me clap once ((students clap)) If you can hear me clap twice ((students clap)) Girls.</u>

> Teacher 4: OKAY, so please sit down, uhh, in groups (3.0) ((students keep talking)) <u>If you can hear me clap once ((students clap)) If you, if you can hear me clap two times ((students clap)), look at me, back to your experimentation spots</u>.

As underscored in the two excerpts shown above, Teacher 4 employs imperatives to direct students who are listening to physically display their listenership ("*if you can hear me clap once*"). By doing so, Teacher 4 initially avoids addressing noncompliant students directly, adopting instead a more indirect directive strategy (i.e., noncompliant students are given a hint) that allows her to request their compliance without calling everyone's attention to their misconduct or bringing it to the foreground. Teacher 4 requests compliant students to display physical listenership twice before resorting to direct and impolite commands such as imperatives ("*look at me*" and "*girls*"). By gradually increasing the level of directness or impoliteness of her directives, Teacher 4 effectively avoids appearing excessively authoritative while attempting to get her students to comply with her commands. As a result, authoritative directive behavior is limited to instances of persistent student misconduct. The above excerpts also illustrate another new discursive feature of Teacher 4's directive behavior which is her frequent employment of the discourse marker "*okay*" (He, 2000). Before giving her directives, Teacher 4 utters the word "*OKAY*" with strong stress, signaling to students that information concerning the goals or procedures of the classroom activity is about to be given. By prefacing her directives with "*okay*," Teacher 4 discursively marks her subsequent utterance, thus increasing the chances that her students will receive them. Such discursive practice was also addressed during the SMIT'N institute, thus explaining its subsequent adoption by Teacher 4.

Subsequent to SMIT'N, Teacher 4 tended to use positive reinforcement while giving whole-class directives. Such indirect discursive strategy was used for instance when Teacher 4 attempted to get her students to settle down in their groups in order to design their behavioral experiment. When students failed to comply with her initial directives, Teacher 4 uttered "*so far, I see Cameron's group is ready, nobody else is ready that I see, who else is ready? (3.0) Cameron's group is making the big decision between line paper and plain paper, who else is making that decision?*" Teacher 4 makes reference to or reinforces the exemplary type of behavior she desires from her students, at the same time indirectly and politely requesting other students to comply.

Teacher 4 also used her whole-class directives to reinforce the social role that she wanted her students to play while engaged in classroom inquiry. For example, while students were conducting their inquiries on crayfish behavior, Teacher 4 gave the directive "<u>*scientists*</u>*, may I* *have your attention just for a second?*" Such utterance serves not only to get students to attend to her talk but also to reinforce the social behavior or attitude that Teacher 4 expects from them.

Summary

As described above, there were several differences between Teacher 4's pre and post inquiry-based classroom discourse. Prior to SMIT'N, Teacher 4 facilitated an asymmetric whole-class discussion, positioning herself authoritatively through the adoption of interactional strategies such as following IRE and IR turn taking structures, asking display questions, repeating all of her students' responses verbatim (implicit positive evaluations), skipping most negative evaluative moves, adopting a questioning approach focused on student recall of scientific terms, making limited and ineffective use of poetic language (resulting in low student involvement), and hedging infrequently. In sharp contrast, subsequent to SMIT'N, Teacher 4 was able to facilitate a whole-class discussion with a more symmetric social structure, positioning herself less authoritatively in relation to her students by effectively employing interactional strategies such as providing reactive tokens and backchannels (instead of continuous verbatim repetitions of students' responses), explicitly encouraging students to listen to each other, employing hedges more often (instead of skipping negative evaluative moves), explicitly stating her lack of knowledge about certain aspects of crayfish behavior and biology, asking more open-ended and rhetorical questions, adopting a questioning approach focused on students' previous experiences (rather than on student recall of scientific terminology), and employing poetic language more frequently and efficiently (leading to higher student involvement or engagement).

Similarly, participation in the SMIT'N institute encouraged Teacher 4 to interact differently with small student groups engaged in classroom inquiries. Prior to SMIT'N, Teacher

4 tended to employ “I/you” contrastive pairs to position herself asymmetrically as a distant and authoritative evaluator, encouraged students to view their classroom inquiry as a group effort aimed primarily at meeting her authoritative or evaluative expectations, used imperatives and direct directives to deal with student misconduct, commanded rather than suggested experimental procedures to students who experienced difficulties, focused exclusively on students’ procedures while giving directives. Conversely, after SMIT’N Teacher 4 employed the inclusive “*we*” to position herself closer and more symmetrically and take on the social role of a group member, encouraged students to view their classroom assignment as an authentic inquiry endeavor, emphasized the need for students to pose and pursue sincere or genuine research questions (i.e., interesting, unanswered, and testable queries), gave physical, cognitive and textual directives to student groups (rather than focusing exclusively on students’ experimental procedures).

It could be argued that the above changes in Teacher 4’s interactional behavior may simply be the result of contextual differences between pre- and post-institute lessons (i.e., different science topics and students) rather than Teacher 4’s actual participation in the SMIT’N institute. However, the fact that Teacher 4 invariably adopted discursive strategies that were consistent with interactional views she expressed during the institute supports the latter interpretation.

Teacher 15’s Inquiry-Based Discourse

Pre-Institute Interactional Strategies

Prior to her participation in the SMIT’N summer institute, Teacher 15 had her group of approximately 15 fourth graders conduct a hands-on classroom investigation on the motion of rolling spheres. The video-recorded investigative activity was an adaptation of an inquiry lesson entitled “*Rollers”* which is part of the FOSS Balance and Motion Module for Grades 1 and 2

(Lawrence Hall of Science, 2005). At the beginning of the lesson, Teacher 15 facilitated a whole-class discussion in which she elicited students' prior knowledge and introduced several physical concepts related to the motion of objects, including friction, force, momentum, and energy (both potential and kinetic forms). In the exploratory part of the lesson, students were given the task of engineering a new rollercoaster for a southern Indiana amusement park. Working in groups of three or four, students used the provided materials - 2 marbles, 4 plastic foam runway sections, 3 pipe cleaners, masking tape, string, straws, toothpicks and other miscellaneous items - to make a rollercoaster model in which the car (i.e., a marble) could roll nonstop through two hills and a 360-degree loop before reaching a safe stopping point (see Figure 5.10). At the end of the lesson, Teacher 15 asked student groups to describe, compare, and demonstrate their rollercoaster creations. The discourse analysis provided below focus exclusively on the initial whole-class discussion.

Figure 5.10 – Teacher 15 discussing rollercoaster design with a group of students.

While facilitating the first half of the whole-class discussion, Teacher 15 tended to adopt several non-authoritative discursive strategies, positioning herself symmetrically in relation to her students. One non-authoritative discursive strategy often employed by Teacher 15 was to avoid providing explicit positive evaluations while interacting with students. For instance, at the beginning of the discussion, Teacher 15 asked students whether it would be possible for someone to ride a hypothetical bicycle with square wheels downhill without applying any force to its peddles:

> Teacher 15: Okay, what if the wheels were square? Adam.
> Adam: Well, umm, it would, the wheels, it wouldn't really turn. It would just, if it was steep enough, it'd kind of shhhhhh down the hill, it'd burn up the bottom.
> Teacher 15: So what is shhhhh? Do you have a word for shhhhhing?
> Adam: SLIDE.
> Teacher 15: <u>It would slide, okay.</u>
> Teacher 15: Rachael, did you want to add something?
> Rachael: Oh, I was gonna say that shhhhh is friction.
> Teacher 15: <u>Ahhhh, friction.</u> So, I've heard two words <u>I'm gonna write down</u>, I've heard gravity and I've heard friction.

When her student Adam uses a placeholder verb ("*sghh*") to express the idea that, even though the wheels would not turn, a square-wheeled bicycle could possible move downhill on a sufficiently steep inclined plane, Teacher 15 immediately requests a clarification. When Adam identifies "*slide*" as the intended referential meaning for the verb "*to sghh*," Teacher 15 reacts by providing a verbatim repetition which is followed by the relatively neutral non-verbal token "*okay*." Teacher 15's verbatim repetition serves an implicit positive evaluation. In contrast, when her student Rachel proposes that "*sghh*" could also refer to "*friction*," Teacher 15 provides a stronger form of implicit positive evaluation. She prefaces her verbatim repetition with the discourse marker "*ahh*," orally highlighting the word friction as being important for the ongoing discussion, thus affirming Rachel's idea by creating the impression of excitement and surprise (see Chapter 4). Teacher 15 then decides go ahead and write the word "*friction*" on the board. Not only does Teacher 15 orally express a strong positive orientation toward Rachel's idea through her use of the discourse marker "*ahh*," but she also provides a form of official endorsement by writing it on the board. This endorsing function stems primarily from the fact that Adam's term "*slide*" is not transcribed on the board (i.e., it is not as important as the notion of "*friction*"). Throughout the lesson, Teacher 15 continued to provide implicit positive evaluations to her students by repeating their oral contributions aloud and by selectively writing them on the board.

Teacher 15 also tended to avoid providing explicit negative evaluations to her students. This non-authoritative and evasive discursive strategy was utilized by Teacher 15 while conducting a demonstration in which she placed a marble on a table and then asked students whether they considered such stationary object to have energy or not:

Teacher 15: Does that marble right there have any energy in it? Michaela.
Michaela: No::
Teacher 15: <u>You say *no*?</u>
Michaela: It has, it has to actually be pushed to have energy.
Teacher 15: Nathan.
Nathan: I think it does have force, I mean, energy.
Teacher 15: Why?
Nathan: Because it's not moving.
Teacher 15: So, it has energy because it's, explain it.
Nathan: To keep it from moving.
Teacher 15: <u>Oh, to keep it from moving, interesting.</u>
Student3: I do too.
Teacher 15: Umm, why?
Student3: Because, umm, I mean, the most like uncommon things you think you wouldn't expect are usually true, and also <u>you went *interesting*</u>.
Teacher 15: <u>Oh,</u> <u>I led you</u> ((laughs))

When Michaela replies negatively, Teacher 15 reacts by providing a verbatim repetition prefaced with an attribution shield ("<u>*you say*</u> *no?*") that allows her to adopt a relatively neutral stance toward Michaela's response while requesting an elaboration or justification. Next, Michaela justifies her negative response by arguing that "*it* [the marble] *has to actually be pushed to have energy*." However, Teacher 15 makes no reactive move, choosing instead to allow Nathan to take over the discussion floor. In sharp contrast, when Nathan proposes that the stationary marble does in fact have energy "*to keep it from moving*," Teacher 15 reacts differently. Like in the previous excerpt, Teacher 15 provides an implicit positive evaluation in the form of a verbatim repetition prefaced with the discourse marker "*oh*," further reinforcing her positive evaluative stance toward Nathan's idea by uttering the comment "*interesting*." Through her differential reactive behaviors, not only does Teacher 15 avoid providing an explicit negative evaluation to Michaela but she also affirms Nathan's idea, orally marking it as the correct or expected response. Sensing the affirmative or endorsing interactional nature of Teacher 15's response to Nathan, Student 3 then decides to express her support for the idea that the stationary marble has energy ("*I do too*"). Interestingly, when asked to justify her support of such counterintuitive notion, Student 3 immediately points out that she interpreted Teacher 15's previous comment ("*interesting*") as constituting a positive evaluation or endorsement. Such justification encourages Teacher 15 to humorously acknowledge the leading character of her previous reactive commentary ("*oh, I led you*"). Overall, Teacher 15's tendency to avoid explicit negative evaluations and to lead students through indirect affirmation of their responses persisted throughout the whole-class discussion.

In addition to avoiding explicit evaluations, Teacher 15 also refrained from correcting the language used by her students while contributing to the discussion. For instance, early in the discussion, Teacher 15 posed the question "*who here has ever ridden a bicycle on gravel?*" In response, her student Eric (an ESL student from East Asia) started describing his prior experiences with bicycles, mistakenly using the word "bombs" in place of "bumps":

Eric: Umm, on gravel the, umm, the like more lumpy it is, the more friction you have, because of <u>the bombs</u> on the surface of them, the rocks=

Student 2: The bombs? ((smiles friendly))

Eric: Umm, not rejecting the ones that you throw, <u>the bombs</u>, they're tiny, umm, it goes with the tire <u>bombs</u> depending on, if you using a smooth like, umm, biking wheel, umm or like a mountain wheel, if you used a mountain wheel there will be more friction, and would go into each other, so they would like slow you down because there is lumps and then <u>bombs</u> appear like that and yeah and all sorts of things.

Teacher 15: Are you saying bombs like B O M B S?
Eric: Umm, not the ones that explode, no ((smiles friendly))
Teacher 15: That's ((smiles friendly)) I'm just clarifying the word you used.

As indicated above, Eric mistakenly employs the word "bombs" (e.g., "*the <u>bombs</u> on the surface of rocks*" instead of "*the <u>bumps</u> on the surface of rocks*"), encouraging both Student 2 and Teacher 15 to request confirmations ("*the bombs?*" and "*are you saying bombs like B O M B S?*"). In both instances, Eric replies negatively, clarifying that he is not referring to "*the ones that you throw*" or to the "*ones that explode*." Instead of explicitly pointing out that the correct word is "bumps," Teacher 15 suggests in a very indirect manner to Eric that there might be a problem with his linguistic choice ("*I'm just clarifying the word you used*"), thus avoiding an explicit correction of Eric's language use. Such avoidance is interactionally multifunctional. Not only does Teacher 15 save Eric's face by not drawing direct attention to his misuse of the English language (politeness function) but she also avoids positioning herself authoritatively in relation to her students (as a native speaker or language expert).

Despite her continued employment of the above non-authoritative discursive practices in the second half of the whole-class discussion, Teacher 15 tended to adopt a more authoritative questioning approach focused primarily on testing students' knowledge of standard scientific concepts, hence establishing a more asymmetric social structure. For instance, while conducting the marble demonstration, Teacher 15 asked a series of questions to test whether her students were familiar with the concept of potential energy:

Teacher 15: ((holds the marble up)) Does it have more energy now?
Students: Yes, sure.
Teacher 15: ((drops the marble)) What about now?
Students: MORE ENERGY!
Teacher 15: Eric.
Eric: It has more energy when you drop it.

Teacher 15: Why?
Eric: Umm, it has energy by itself to keep it from moving, and then, you drop it, if you drop it on the ground, the gravity will pull it down, will make it go faster in seconds=
Teacher 15: So, what's the force when it's dropping that is acting upon it?
Eric: Gravity.
Teacher 15: Gravity. What's the force that's acting upon it right now ((holding marble))?
Eric: You.
Teacher 15: Me, I'm holding it away from the gravity that wants to take it ((places the marble on table)) <u>the marble right now has energy, it's a specific energy called potential energy</u> ((writes it on the board)).

Teacher 15 starts the above interactions by asking a yes-or-no question ("*does it* [the marble] *have more energy now?*") followed by a series of wh-questions ("*What about now?*", "*Why?*" and "*What's the force that's acting upon it right now*?"). It is noteworthy that Teacher 15 employs no hedges (e.g., might, can, possibly) or *you*-prefaces (e.g., what do you think…?), and as a result her queries start to resemble display questions, that is, insincere and authoritative information requests posed by a science expert to a group of novices in order to test their scientific knowledge. Furthermore, Teacher 15 initially skips evaluative third moves, leading to the occurrence of four IR turn taking sequences. However, later she shifts into an IRE interactional mode by providing two implicit positive evaluations in the form of verbatim repetitions ("*gravity*," and "*me*"). At the end, Teacher 15 places the marble back on the table, finally revealing that the right answer to her previous question is that the stationary marble has what scientists call potential energy. This prolonged withholding of the "right" answer from students was characteristic of Teacher 15's authoritative questioning approach.

The authoritative interactional patterns described above recurred later in the marble demonstration when Teacher 15 proceeded to test her students' knowledge of the concept of kinetic energy. Once again, the questioning approach adopted by Teacher 15 served to establish an asymmetric social structure:

Teacher 15: ((makes the marble roll on table)) When it's moving, does it have potential energy?
Students: UMM
Teacher 15: UMM::: ((laughs)) That was a non-committal UMMM ((laughs)), Nathan go ahead.
Nathan: No, because it's reducing the energy.
Teacher 15: Umm, I flicked it, I took a force and I bashed it, I took its potential energy and moved it forward, I therefore, does anybody know the name of the transference of energy that I just did to it? ((grabs a blanket and place it on table)) Will I need more or less energy to push it across here?
Mathew: More.
Teacher 15: Mathew says more here, more across.
Mathew: It's like the gra, the gravel, just like the gravel.
Teacher 15: Ahh, if you were riding your bicycle through the grass that looks blue and green like this, it would take more force to move it forward, our potential energy, <u>when it is transferred</u>, <u>when it is dropping</u>, ((drops marble)), <u>when it is going across the table,</u> ((places marble on table)), <u>it's called kinetic energy</u> ((writes it on the board))

Teacher 15 starts the above interactions by posing another display question ("*when it's moving, does it* [the marble] *have potential energy?*"). Sensing that Teacher 15 is once again testing them, students respond by employing the non-verbal token "*umm*" as a hedge, hence avoiding committing themselves entirely to an affirmative or to a negative answer. Students' hedging behavior serves as an oral defense mechanism. By remaining uncommitted to a particular answer, students protect themselves from the possibility of failing Teacher 15's latest display question. Faced with such elusive discursive maneuvering, Teacher 15 utters a prolonged and exaggerated verbatim repetition ("*umm:::*") and then humorously comments on the students' clear lack of commitment to their response ("*that was a non-committal umm*"). When her student Nathan finally commits to a negative answer ("no, because it's reducing the energy"), Teacher 15 reacts by uttering the relatively neutral hedge "*umm,*" immediately resuming the marble demonstration. Likewise, when Mathew proposes that it takes more energy to move the marble across the table covered with a blanket, Teacher 15 prefaces her reactive comment with an attribution shield ("*<u>Mathew says</u> more here, more across*"). In both cases, Teacher 15 resorts to hedges in order to adopt a relatively neutral stance toward the students' responses, that is, she avoids committing herself entirely to a positive or negative evaluation. In contrast, when Matthew proposes that moving the marble on a blanket is similar to riding a bicycle on grass, Teacher 15 provides a marked verbatim repetition ("*ahh, if you were riding your bicycle through grass… it would take more force to move it forward*"), thus affirming Mathew's response. At the end, Teacher 15 utters a series of parallel repetitions ("*when it is transferred, when it is dropping, when it is going across the table, it's called kinetic energy*"), thus strategically seeking to increase student involvement just before revealing that the right answer to her initial question is that moving objects have a different form of energy that scientists call kinetic.

Throughout the whole-class discussion, Teacher 15 was able to maintain a high level of student involvement through her skilful and frequent employment of poetic language. For instance, Teacher 15 often employed poetics while reacting to students' responses to her questions:

> Teacher 15: Umm, who here has ever ridden a bicycle on gravel? ((students raise their hands)) Umm, is it easier to ride on gravel than on flat pavement? (1.0) Matthew, you are shaking your head, why do you say *no* so vigilantly?
> Matthew: Cause it's the gravel and it tries to stop you, because it's bumpy.
> Teacher 15: The gravel tries to, it has a mind of its own, and it reaches up and grabs the spokes of your bicycle, and stops you ((laughs)).

> Teacher 15: There's still a word I'm looking for, we'll see if we can get to it, Gordon.
> Gordon: Force?
> Teacher 15: The force (1.0) May the force be with you ((laughs))

> Teacher 15: Gravity. What's the force that's acting upon it right now ((holding marble))?
> Eric: You.
> Teacher 15: Me, I'm holding it away from the gravity that wants to take it.

As indicated in the above excerpts, Teacher 15 resorts to poetic language while providing reactive comments on her students' responses or ideas, including two personifications ("*the* *gravel reaches up and grabs the spokes of your bicycle*," and "*the gravity wants to take it*") and a idiomatic expression made popular by the movie Star Wars ("*may the force be with you*"). Such linguistic forms clearly do not serve an informational function, that is, Teacher 15 does not use them to improve students' understandings the concepts of force and gravity. Instead, Teacher 15 is seeking to foster student involvement in the whole-class discussion by strategically employing amusing or engaging speech.

Teacher 15 also employed poetic language while posing questions and while giving directions to her students. For instance, at the beginning of the whole-class discussion, while eliciting her students' prior knowledge and experiences, Teacher 15 uttered the following "*OKAY, who here has ever, in the winter, we talked about gravel, <u>winter, ice, bicycle</u>* ((all students raise their hands))." Instead of finishing the question she starts to pose ("*who has ever ridden a bicycle in the winter*?"), Teacher 15 aborts and then replaces it with a triplet, that is, parallel repetitions of three nouns ("*winter, ice, bicycle*"). Similarly, while giving instructions to her students about the rollercoaster inquiry, Teacher 15 gave the following directive "*OKAY (2.0) these are your instructions (2.0) your roller coaster must have a name, <u>that's gonna be extremely difficult for you</u>*." As indicated, Teacher 15 resorts to an irony, sarcastically describing the need for student to name their roller coasters as constituting a very difficulty requirement when in fact she means that it is a very easy task for students to accomplish. In both cases, Teacher 15 is able to foster involvement among her students who do not seem to be confused by her poetic and non-literal forms of speaking.

Teacher 15's employment of personal pronouns was also pretty consistent throughout the whole-class discussion. In very few instances, did Teacher 15 resort to the solidarity-building pronoun "*we*," favoring instead the employment of "*I/you*" contrastive pairs. This interactional tendency is illustrated in the excerpt provided below, which took place at the beginning of the discussion, when Teacher 15 asked her students to describe their previous experiences with bicycles:

> Teacher 15: I've heard you say moving, that the bike is moving, and I've heard you say propelling and pushing, do you wanna try it?
>
> Agnes: Umm, when you're going down the hill, like you just move, if you kick, put up your kickstand, you just move, umm, you just move down, but if you're on a flat surface, I find that, umm, if I go really fast, then you like bring up the momentum.
>
> Teacher 15: Okay, so you have the momentum going?
>
> Agnes: [umhm
>
> Teacher 15: [which will keep you going.

As shown above, not only does Teacher 15 employ "*I/you*" contrastive pairs while eliciting her students' prior experiences, but she also resorts to the distancing second-person pronoun "*you*" while reacting to Agnes' response ("*so you have the momentum going?*") and while providing her with conceptual feedback ("*which will keep you going*"). As a result, Teacher 15 separates herself from her students, adopting a distant interactional positioning. Despite this distancing interactional tendency, Teacher 15 was able to foster a fairly symmetric social structure while facilitating the first half of the whole-class discussion through strategic employment of the non-evaluative discursive strategies described above.

Teacher 15's directive behavior also tended to be authoritative and interactionally distant when addressing the whole class. For instance, after bringing the whole-class discussion into a closure, Teacher 15 gave the following directives to her students "*what you're gonna do today, I've kept it secret and I am really happy that I have, you, my lovely new engineers of the world, you have all been hired by the new southern Indiana… you all are in charge of the design for the new amazing, wonderful attraction… you, are designing, a roller coaster*." As indicated, Teacher 15 employs the distancing pronoun "*you*" several times while giving whole-class directives. Nonetheless, she seems to compensate for such authoritative practice by uttering affectionate comments such as "*my lovely engineers of the world,*" which serves not only to avoid sounding excessively authoritarian but also to reinforce the social role that she expects her students to play while engaged in the classroom inquiry.

Another authoritative directive behavior employed by Teacher 15 was her tendency to give what could be considered linguistically impolite and direct commands such as the following "*you <u>must</u> have a starting hill, you <u>must</u> also have a 360 degree loop, and another full hill, up on one side and down the other, starting on a hill, in any order, you <u>can</u> go up and down another hill, then through the loop or vice-versa, you <u>must</u> have a safe stopping point*." As can be seen, while explaining the requirements of the rollercoaster inquiry to her students, Teacher 15 gives four *you*-prefaced declaratives (three with the mandatory verb "*must*" and one with the optional verb "*can*"). Consequently, Teacher 15 marks her authoritative status by conveying a strong sense of obligation on the part of her students.

Post-Institute Interactional Strategies

Subsequent to her participation in the SMIT'N summer institute, Teacher 15 was video-recorded while implementing a classroom investigation on self-propelled cart models. This investigative activity was based on an inquiry lesson entitled "*Go-Carts*" which is part of the FOSS Models and Design Module for Grades 5 and 6 (Lawrence Hall of Science, 2005). Her inquiry lesson was divided into three main parts. First, Teacher 15 facilitated a whole-class discussion focused on scientific and technological concepts, including models (both conceptual and physical), scaling, and simple machines -- wheel and axle, lever and inclined plane (see Figure 5.11 below). In the second part, students were provided with an assortment of common construction materials, including wooden wheels, dowel rods, clothespins, rubber bands, brads, binder clips, and paper clips. While working in pairs, students were asked to design, build, test, and improve self-propelled model carts, relating particular physical structures to functions like engineers normally do. In the third and last part of the lesson, Teacher 15 facilitated a second whole-class discussion in which she asked student pairs to share their difficulties, findings, and design ideas with peers. The discourse analysis provided below focus exclusively on the initial whole-class discussion, comparing it to the pre-institute discussion about energy and force.

Figure 5.11 – Teacher 15 facilitating a whole-class discussion on models and simple machines.

As pointed out in the previous section, prior to attending the SMIT'N summer institute, Teacher 15 tended to employ both authoritative and non-authoritative discursive strategies, positioning herself sometimes symmetrically and at other times asymmetrically in relation to her students. In contrast, while facilitating the post-institute whole-class discussion, Teacher 15 made use primarily of non-authoritative linguistic forms, hence establishing a more stable and symmetric social structure that persisted throughout the discussion. For instance, rather than providing implicit positive evaluative comments in the form of verbatim repetitions (her pre-institute reactive behavior), Teacher 15 tended to react to her students' ideas by providing neutral and informative feedback. This discursive strategy was employed by Teacher 15 while eliciting her students' prior historical knowledge with regard to the invention of wheels:

Teacher 15: WHEELS are beautiful things that have been around since, umm, you know, five thousand years, they've been around, <u>what do you think</u> the first wheel was created to do? Liz.
Liz: Well, I watched a show and there they said that was, they used to move things where they just laid it on it and then you'd like put them on it, the wheels, and then you pushed them along to get them where you wanted them to go.
Teacher 15: <u>Okay, so working in, you know, similar to the lever where we were lifting something up, it's that, that simple machine that helps move something</u>.

Teacher 15 starts off the above interactions by posing a *you*-question ("*<u>what do you think</u> the first wheel was created to do?*"), encouraging students to articulate their own ideas or thoughts rather than attempting to provide what the teacher considers to be the right answer. In response, her student Liz suggests in a somewhat unclear manner that the wheel was invented for the purpose of making transport of objects easier for humans ("*to move things*"). While commenting on Liz's response, Teacher 15 first utters the neutral reactive token "*okay*" and then offers a candidate understanding (Waring, 2002) in which she points out that the simple machines known as levers serve a similar function which is to help humans move objects around. As result, Teacher 15 is able to reactively inform her students while maintaining a relatively neutral stance toward Liz's idea. Such an informative and neutral comment is more closely aligned with a Feedback move than with an Evaluative one. Therefore, it can be argued that the above interaction has an IRF turn-taking structure. Similar interactional patterns recurred later in the discussion when Teacher 15 asked her students to explain the process by which the engine of an automobile produces the rotation of its wheels:

Teacher 15: <u>Does anybody know</u> how an engine works? What about an engine makes the wheels turn? Alex.
Alex: Well, I don't know, is it that an engine has like, the engine like creates force and energy to move the little, to move the axle that moves the wheels, and the way it creates force and energy is from oil, but I don't know how it actually do that.
Teacher 15: <u>So, it's a complicated process, it's essentially what you're saying?</u> It does, uhh, it takes it from that we have originally moved clay, span clay around, and then we put large objects on it and we used to move us forward, and then

> we've peddled, and we now have some type of different engines that move our wheels, and transport heavy objects called us.

As indicated above, Teacher 15 prefaces her opening question with the auxiliary verb "*does*" followed by the indefinite pronoun "*anybody*" and the mental verbal "*know*." By asking a yes-or-no question with an indefinite pronominal form, Teacher 15 seems to discourage her students from interpreting her query as a display question. A query without such preface (e.g., "how does an engine work?") would be more likely to be interpreted by students as constituting a display question. While replying to Teacher 15, her student Alex employs the hedge "*I don't know*" twice, marking his response as being tentative and as having a certain degree of inadequacy or limitation. In response, Teacher 15 reacts by offering a candidate understanding ("*so, it's a complicated process, it's essentially what you're saying?*") which is promptly confirmed by Alex with a headshake. Teacher 15's reactive move serves both face-saving and neutrality functions. By proposing that the functioning of a car engine is a complicated process, Teacher 15 indirectly conveys the message that Alex's uncertainty is understandable and justified, thus politely saving his face. More importantly, Teacher 15 avoids evaluating Alex either positively or negatively, thus adopting a neutral orientation toward his response. Rather than leaving at that, Teacher 15 then starts to provide historical feedback, explaining to students that the complexity of engine-powered wheels is the result of a long process of development undergone by wheels ever since their invention by clay potters. Teacher 15's informative and neutral comments serve as a Feedback move, thus providing evidence that the above interactions followed an IRF discursive pattern.

Teacher 15's adoption of the above discursive practices is directly connected to her participation in the SMIT'N summer institute. As pointed out in Chapter 4, the need for discursive neutrality was addressed on second day of the institute when participants criticized

Mrs. Neuhall's tendency to affirm her students' responses. Similarly, Teacher 15 tended to be excessively leading before the institute, often affirming students' responses by offering marked verbatim repetitions ("*ahh*") and by writing selectively on the board. Teacher 15 discontinued such discursive practices subsequent to the summer institute, favoring instead reactive neutrality. Likewise, the need for teachers to provide feedback to students while guiding classroom inquiries was emphasized on the second day of SMIT'N, thus explaining Teacher 15's post-institute tendency to provide feedback.

The previous excerpts also provide evidence that Teacher 15 tended to employ the solidarity-building pronoun "*we*" while providing feedback to her students. For instance, while providing historical feedback to her student Alex, Teacher 15 resorted to first-person, plural pronominal forms for a total of eight times ("*it takes it from that* <u>*we*</u> *have originally moved clay, span clay around, and then* <u>*we*</u> *put large objects on it and* <u>*we*</u> *used to move* <u>*us*</u> *forward, and then* <u>*we*</u>*'ve peddled, and* <u>*we*</u> *now have some type of different engines that move* <u>*our*</u> *wheels, and transport heavy objects called* <u>*us*</u>"). Such strong emphasis on solidarity is in sharp contrast to Teacher 15's pre-institute discursive tendency to employ authoritative and distancing "*I/you*" contrastive pairs to address students ("*we*" was rarely employed). In other words, participation in the SMIT'N summer institute encouraged Teacher 15 to adopt a relatively closer interactional position or alignment by frequently employing inclusive pronominal forms that fostered the impression of a single classroom social group.

Despite her overall preference for discursive neutrality, Teacher 15 sometimes offered explicit positive evaluations to her students, typically following her evaluative comments with feedback information. One of the very few instances in which Teacher 15 employed such evaluative reactive behavior occurred early in the lesson, when the topic under discussion was the nature of conceptual models:

Teacher 15: Mac.
Mac: I was just, it's about, like the conceptual models, they can also be called mental models.
Teacher 15: Mental models, mental ((joking)), that's right, because it starts in your head but, umm, if you're wanting to share what's inside of your head, you don't just usually walk up to Gabe and press your head against his ((press her head against his head)) and hope that whatever thoughts that are inside of yours flow into his ((laughs)).

As can be seen above, when her student Mac proposes that conceptual models can also be called "*mental models*," Teacher 15 does not react in a neutral manner. Instead, she repeats Mac's idea verbatim, utters an explicit positive evaluation ("*that's right*"), and then immediately starts to provide Mac with feedback, informing him that such models can also be called mental because they are located inside someone's head and for this reason are physically inaccessible to others. Given her lack of discursive neutrality, it can be argued that Teacher 15's reactive comments constitute an evaluative Feedback move (as opposed to neutral feedback). Put differently, the above interactions have an IRF structure even though the third move is explicitly evaluative. Therefore, it can be concluded that what sets IRE and IRF sequences apart is the informative nature of the third move rather than its discursive neutrality, that is, in IRE sequences, the teacher's third move merely informs students whether they are right or wrong, nothing else.

In addition to continuously providing feedback, Teacher 15 also encouraged her students to evaluate themselves. Such strategy was employed early in the discussion when Teacher 15 asked her students to explain why engineers often devote their time and effort to constructing scaled-down models before implementing large construction projects such as designing a new state building or a go-cart:

Teacher 15: Miranda, what do you think?
Miranda: Because what if they don't like it? Like, you can make this huge go-cart, and then like the people don't like it, then it's just basically a waste of your time.
Teacher 15: <u>What is another benefit to making a little model?</u> Roger.
Roger: Well, if there is a flaw in your design, then you can just fix it, it's easier to work with.
Teacher 15: So, a flaw like you're going from your conceptual idea that *I know this is gonna work exactly how I want it to work*, *I've drawn it out*, *I know it's gonna work*, and then you go straight to building the full-sized model, you get in it, and you're like *Ooh, nothing happened* ((disappointed tone)). What if you have to start back from scratch? Back to a conceptual model, make your little tweaks, and then build it all in full again?

Teacher 15 starts off by posing an open-ended *you*-question ("*what do you think?*"), encouraging students to articulate their own thoughts or ideas rather than provide her with the right answer. However, instead of supporting the use of scaled-down models (as Teacher 15 expected), her student Miranda provides a response in which she opposes such practice, arguing that the construction a model can be a waste of time and effort because the proposed model can be potentially rejected by buyers, investors or other interested parties. Teacher 15 then reacts by requesting her student Roger to identify a potential benefit of scaled-down modeling. In other words, Teacher 15 avoids providing an explicit negative evaluation by skipping the third move, hence leading to the occurrence of an IR sequence. When Roger proposes that small models are easier to work with (e.g., to correct design flaws), Teacher 15 then reacts by providing a candidate understanding that informs students that it would be significantly more difficulty for an engineer to fix a full-sized model of a building. Teacher 15's reactive comments constitute a neutral Feedback move (see above). More importantly, Teacher 15 provides Miranda with feedback information that will allow her to evaluate and possibly reconsider her previously expressed opposition to modeling on her own.

Adoption of the above discursive strategy is a direct consequence of Teacher 15's participation in the SMIT'N summer institute. As pointed out in Chapter 4, on the second day of the institute, Teacher 15 and other participants argued that instructors should concentrate their efforts on providing students with feedback that can enable them to evaluate themselves and interconnect science-related ideas rather than simply withholding evaluations from students. The above excerpts provide evidence that Teacher 15 in fact implemented such a view of inquiry-based instruction by prioritizing provision of feedback over withholding of evaluations. Such a feedback-centered view accounts for the fact that Teacher 15 invariably offered informative reactive comments even though she did not always adopt a neutral orientation toward her students' responses and ideas.

Throughout the discussion, Teacher 15 tended to adopt a substantially less authoritative questioning approach than she did prior to participating in the SMIT'N institute. Rather than testing students' knowledge of standard scientific concepts, Teacher 15 adopted a more symmetric line of questioning aimed primarily at encouraging students to articulate their own thoughts and ideas, at the same time building solidarity and providing them with informative feedback. This non-authoritative questioning practice was adopted for instance during the discussion about scaled-down models:

Teacher 15: So, <u>we</u>'ve talked about cost, <u>we</u>'ve talked about possible design flaws that you would need to change, umm, time and energy, it might be easier to use little popsicle sticks, and then take that and think *umm, what do I need to do to make this something that I can fit inside of*? Ian.

Ian: Maybe you want that to be your prototype, I think you will go back to the drawing table.

Teacher 15: <u>Is that what it is? If they say that this is the prototype of our new hydrogen-powered car?</u>

Ian: It's like they make some of a consumer product.

Teacher 15: <u>Exactly</u>, what a prototype is that, Luisa what is it?

Luisa: It means that you build a model that actually works, and the one that you actually use.

Teacher 15: It's that next step, Ian, after you take in your conceptual model, you make your little, tiny, your, not your tinny, sometimes they are big, actual models, you tweak it, find the things that might not work well, get it to the best possible design that you can think of, then you make this big prototype, and

> the prototype still might need to have some changes, but it's that next, it's the one that they invest the money into. They invest the time and you, it's, it's the car that you can actually sit inside of.

While summarizing the previously discussed benefits of constructing small models, Teacher 15 seeks to foster solidarity with her students by employing the inclusive personal pronoun "*we*" twice. She also illustrates the cognitive or thinking aspects of small-scale modeling, posing the type of question that engineers or designers normally need to ask themselves after constructing a miniature model ("*umm, what do I need to do to make this something that I can fit inside of*?"). Next, her student Ian mistakenly proposes that the scaled-down model that Teacher 15 is referring to can possibly constitute a prototype. Rather than providing a negative evaluation or explicitly pointing out that a prototype is actually a full-sized model, Teacher 15 reacts with a reflective toss (van Zee & Minstrell, 1997a; b), that is, a reactive move that throws the responsibility of thinking back to the student ("*Is that what it is? If they say that this is the prototype of our new hydrogen-powered car?*"). It must be noticed that Teacher 15's reactive questions have a yes-or-no format and a solidarity-building pronoun ("*our*"), linguistic features that serve to create the impression of a sincere or genuine request for information (as opposed to an authoritative display question). Such reactive move effectively encourages Ian to elaborate on his understanding of prototype ("*it's like they make some of a consumer product*"). In response, Teacher 15 provides an explicit positive evaluation ("*exactly*") and then asks her student Luisa to define what a prototype is ("*Luisa, what is it?*"). When Luisa complies, Teacher 15 then makes a Feedback move (rather than an Evaluation), providing a detailed description of the entire sequence of modeling steps typically followed by engineers in order to develop or design a new car: conceptual model, scaled-down model, prototype, and finally the actual model. Such an informative reactive move leads to the occurrence of an IRF sequence. Overall, Teacher 15 is able to establish a symmetric social structure by adopting a questioning approach in which responsibility and authority over the task of clarifying the nature of engineers' modeling activity is continuously shared with students.

Another important feature of Teacher 15's post-institute questioning behavior was her tendency to pose questions whose primary function was to foster student involvement in the discussion rather than to further students' emergent understandings of scientific models. Such involved questioning strategy was adopted by Teacher 15 when she asked her students to describe how her student Roger could possibly approach the hypothetical task of designing the interior of a new state building for Indiana:

> Teacher 15: <u>Would he [Roger] go over there [to the old building] with a big chainsaw?</u>
> Holly: No ((laughs))
>
> Teacher 15: Now, <u>would he [Roger] go and make a full state building, and say *hey guys, do you want it?*</u>
> Students: No ((laughs))

In both of the above instances, Teacher 15 asks yes-or-no questions in which she proposes design approaches that are clearly unreasonable and impractical (to cut the old building open with a big chainsaw, and to construct a full-sized building and then attempt to sell it). Instead of eliciting new information from the students (i.e., serving a cognitive function), such convergent and arguably obvious queries serve a social or interactional function which is to foster student involvement in the discussion by means of humor or amusement. In both cases, students react to Teacher 15's questions with laughter, providing negative responses without any justification or added information.

Similarly, when the topic under discussion was wheels, carts and cars, Teacher 15 also asked a few involvement-focused questions that did not seem to serve primarily a cognitive function:

Teacher 15: If I asked you to make a go-cart, and told you that you have thirty minutes to do it, do you think you would be making one that you could sit in?
Students: NO ((laughs))

Teacher 15: Do you peddle your car?
Students: No, no ((laughs))
Teacher 15: Would you like to peddle a car?
Students: NO, NO, YES, YES ((laughs))

Like in the previous excerpts, Teacher 15 asks several convergent questions with a yes-or-no format, eliciting laughter as well as short affirmative or negative responses from her students, but no new information, justification or elaboration. Again, Teacher 15 is able to effectively foster student involvement in the discussion by strategically asking questions that are both amusing and humorous, therefore demonstrating an ability to skillfully use questions for non-cognitive purposes. Such ability is directly related to her participation in the SMIT'N summer institute. As pointed out in Chapter 4, on the second day of the institute, participants were encouraged to recognize that teachers' questions were not neutral requests for information, and that they served not only cognitive functions (e.g., eliciting students' prior knowledge) but also a variety of interactional or social functions (e.g., testing students' knowledge, encouraging student participation, fostering involvement, etc.). Such experiences increased Teacher 15's awareness of the interactional or social aspects of teacher questioning, thus enabling her to exploit them subsequent to SMIT'N.

Overall, Teacher 15 was able to maintain a high level of student involvement throughout the whole-class discussion. In addition to frequently asking involvement-focused questions, Teacher 15 also continued to make effective employment of poetic language (her pre-institute interactional strategy). For instance, while discussing with students the mechanism whereby riders are able to make the wheels of their bicycles rotate, Teacher 15 uttered the following "*so again, what is peddling doing? We talked that it's turning the gear* *that turns the chain* *that turns* *the axle* *that turns the wheel* *and hence you go forward*." As underscored, Teacher 15 resorts to a series of parallel repetitions in order to provide a description that not only fosters involvement but is also rich in details and more likely to be recalled by students. Similarly, while discussing the concept of force, Teacher 15 made the following comments "*the force, like Star Wars, she was the force that got to be in the air* ((laughs))." Like in the pre-institute discussion, Teacher 15 seeks to foster involvement by making reference to idioms made popular by the movie *Star Wars*.

Subsequent to her participation in the summer institute, Teacher 15's whole-class directives tended to be relatively less distant and authoritative. Overall, Teacher 15 favored the use of declaratives, sometimes employing polite linguistic devices. For instance, the following whole-class directives were given in different moments of the inquiry lesson:

> Teacher 15: I wanna see if you can put together something that can move without you directly pushing it.
>
> Teacher 15: It is time for us to start cleaning up.
>
> Teacher 15: I would like for you to have a seat where you originally started with your voices off.
>
> Teacher 15: If you're sitting quietly right now with your hands off of the materials, you're doing the right thing.

As can be seen above, Teacher 15 invariable resorts to declaratives while giving commands to her students. More importantly, Teacher 15 employs a polite linguistic formula ("*I would like*") and the solidarity-building pronoun ("*us*"), therefore discontinuing her pre-institute tendency to invariably employ the distancing personal pronoun "*you*" and the authoritative verb "*must*" (see previous section). Such change in directive behavior is likely connected to Teacher 15's participation in the professional activities of the eight day of the SMIT'N summer institute. As described in Chapter 4, participants viewed employment of polite language as being both appropriate and effective for directing when dealing with ordinary classroom situations that do not involve student misbehavior. The above excerpts provide evidence that Teacher 15 began to implement such a view of polite directive behavior after SMIT'N.

Summary

The above discourse analysis provides evidence that Teacher 15's pre- and post-institute interactional performances differed in several aspects. While facilitating the pre-institute whole-class discussion about force and energy, Teacher 15 employed both non-authoritative and authoritative discursive strategies, initially fostering a symmetric interactional structure that became increasingly asymmetric as the discussion unfolded. Teacher 15's non-authoritative discourse strategies included uttering verbatim repetitions to avoid providing explicit positive evaluations, resorting to attribution shields and skipping evaluative reactive moves to avoid providing explicit negative evaluations, refraining from correcting the language used by students, and including affectionate comments in her whole-class directives. Simultaneously, Teacher 15 tended to employ authoritative discursive practices such as adopting a questioning approach focused on testing students' knowledge of standard scientific concepts (combination of display questions and prolonged withholding of the "right" answers), leading students through indirect affirmation of their responses (marked verbatim repetition and selective transcription on the board), favoring the use of "*I/you*" contrastive pairs and the distant personal pronoun "*you*," and giving direct and impolite directives with the mandatory verb "*must*."

In sharp contrast, while facilitating the post-institute whole-class discussion about scientific models and simple machines, Teacher 15 made use primarily of non-authoritative linguistic forms, hence establishing a more stable and symmetric social structure that persisted through the discussion. Among her main non-authoritative linguistic choices were provision of neutral and informative feedback (in the form of nonverbal reactive tokens followed by candidate understandings), favoring reactive neutrality over discursive affirmation of students' responses (adoption of leading reactive behaviors was discontinued), tendency to interact through IRF sequences, frequent employment of the solidarity-building pronoun "*we*," adoption of reactive moves that encouraged students to evaluate themselves and to do the thinking (reflective toss), adoption of a less authoritative questioning approach focused on encouraging students to articulate their own thoughts and ideas, and preference for less distant and authoritative whole-class directives (often in the form of polite declarative statements).

Another important aspect of Teacher 15's inquiry based discourse was her ability to establish and maintain a high level of student involvement while facilitating whole-class discussions. Even though such ability was equally demonstrated by Teacher 15 both prior and subsequent to SMIT'N, her involvement-focused linguistic strategies seemed more varied after the summer institute. During the pre-institute discussion Teacher 15 was able to foster high levels of student involvement through efficient use of poetic language (parallel repetitions, speech figures, and idiomatic expressions). In contrast, after SMIT'N, not only did Teacher 15 continue to employ poetic language but she also made frequent use of involvement-focused questions (humorous and amusing queries that served primarily non-cognitive interactional functions).

The above differences in Teacher 15's pre and post interactional performances can be explained in terms of contextual discrepancies such as the distinct science topics being investigated and the different groups of students present in the room. However, because the above changes in Teacher 15's interactional performances were consistent with the interactional views she expressed during the institute, it can be argued that a better explanation is that such changes were in fact a result of her participation in SMIT'N.

Chapter 6

DISCUSSION

Introduction

In this last chapter, I review and discuss the findings of my grounded theory and microethnographic analyses (described in Chapters 4 and 5, respectively). More specifically, I highlight the significance and relevance of the results presented in previous chapters, drawing empirical and theoretical connections to current research on language-mediated classroom interaction and addressing issues recently raised in the literature on teacher education. The discussion is organized according to the research questions posed in Chapter 1, focusing first on *the impact of SMIT'N on elementary teachers' views of classroom inquiry*, and second on *the impact of SMIT'N on elementary teachers' inquiry-based classroom practices*. After this discussion, I consider the implications for inquiry-based professional development and science teaching, and provide an account of the limiting aspects of the methods of data collection and analysis that I employed to investigate the SMIT'N institute and teachers' science inquiry lessons. I then describe how the findings of the present study inform future steps in my research agenda with regard to inquiry-based classroom discourse, and end the chapter with a summary of findings and implications of the present study.

The Impact of SMIT'N on Teachers' Views of Inquiry

While participating in the SMIT'N institute, elementary teachers seemed to develop a new conception of inquiry-based science instruction centered on the notions of classroom discourse and teacher-student interaction. As detailed in Chapter 4, there was a gradual shift in teachers' views from a cognitive, monofunctional and decontextualized perspective on inquiry-based classroom discourse to a stance that took into account the social, multifunctional and contextualized nature of the language used by teachers to address students engaged in classroom inquiries. Rather than continuing to view inquiry-based teacher-student verbal exchanges as serving exclusively cognitive ends (i.e., promoting and supporting student scientific thinking), participants were gradually able to recognize that teachers' speech behaviors -- questions, responses, hedges, directives, personal pronouns, poetic language, phatic language -- also served a variety of interactional functions such as fostering involvement, inclusiveness, politeness, solidarity, sincerity, neutrality, and symmetricality. This change in elementary teachers' views of classroom inquiry appeared to be the result of a professional development approach that combined expert instruction on educational linguistic research, immersion in scientific inquiry, and collaborative discourse analyses of immersion experiences and video-recorded inquiry lessons.

Previous research in the field of science education has examined the impact of methods courses on pre-service teachers' views of inquiry and nature of science (NOS). Although not focused specifically on teachers' interactional views, this literature contains several descriptions of interventional formats shown to be effective in promoting improvements and initiating changes in teachers' views. To improve elementary teachers' NOS views, some science educators have successfully adopted an "explicit reflective" approach in the context of elementary science methods courses (Abd-El-Khalick & Akerson, 2004; Akerson, Abd-El-Khalick, & Lederman, 2000). These studies have reported substantial improvements in preservice teachers' NOS views through a combination of explicitly-focused, generic activities and whole-class, reflective discussions about NOS. Akerson and her collaborators argue that, rather than simply assuming that teachers' views develop implicitly through participation in science inquiry activities, science educators need to provide teachers with opportunities to reflect about NOS (both orally and in writing) and encourage them to articulate improved and informed NOS understandings through instruction, discussion and questioning.

The present study provides evidence suggesting that elementary teachers' interactional views can also be effectively improved through an explicit reflective professional development approach. Like the NOS interventions described above, the SMIT'N institute provided teachers with numerous opportunities to reflect about the interactional dimension of inquiry-based science instruction. Furthermore, elementary teachers were encouraged to articulate explicit and more informed interactional views of classroom inquiry by discussing current educational linguistic research (morning expert instruction sessions), critiquing teacher-student interaction in the context of their inquiry immersion experiences (afternoon collaborative assessment sessions), conducting video-based collaborative discourse analyses, writing reflective reports, and sharing the findings of their collaborative discourse analyses with peers (PowerPoint presentations). Based on the observed changes in teachers' interactional views, it can be concluded that explicitness and reflectivity are essential features of professional development programs aimed at improving teachers' understandings of the social characteristics of the inquiry-based science classroom.

Several educational researchers have emphasized that professional development programs need to be contextualized in order to effectively produce changes in teachers' views, beliefs and understandings. Clough (2006) advocates the use of highly contextualized NOS instruction -- authentic instructional activities that integrate specific science content as well as information about its historical development -- as a means for developing deep NOS understandings in teachers. Schwartz, Lederman, & Crawford (2004) also identify context as an important factor for the development of teachers' NOS views. More specifically, they argue that scientific inquiry activities provide authentic contexts for teachers to engage in meaningful reflection about the nature of science. Furthermore, Schwartz and her colleagues describe how engagement in contextualized reflection -- oral discussions and journal writing activities -- encouraged a group of preservice secondary teachers to articulate explicit connections between their science conceptions and inquiry experiences, leading to a substantial improvement in their NOS views. Similarly, Yerrick, Parke and Nugent (1997) argue that decontextualized discussions and collaborative activities commonly found in summer institutes are unlikely to promote deeply rooted changes in teachers' beliefs and interpretations of inquiry-based approaches to science instruction. Because such professional development activities are excessively removed from schools, students and classrooms, they fail to elicit much of the contextualized forms of thinking that teachers are required to perform in their daily tasks. To make a lasting and deeply rooted change in teachers beliefs, Yerrick and others argue, professional developers need to "help teachers reflect on and in their action as professionals."

Based on the above recommendations and perspectives on teacher education, it can be argued that the observed changes in the elementary teachers' interactional views of classroom inquiry are likely to be connected to the high level of contextualization and authenticity of the SMIT'N professional development activities. The inquiry immersion experiences provided participating teachers with an authentic instructional context (i.e., investigative and content-specific) in which to reflect about inquiry-based science classroom discourse. Furthermore, the video-recorded inquiry lessons allowed teachers to (re)consider their interactional views in light of critical examinations of their own daily discursive actions and to engage in highly contextualized reflections (both orally and in writing) about the social dimension of inquiry-based science instruction in their own classrooms. It is probable that elementary teachers' understandings improved as a result of engaging in collaborative activities and discussions about classroom social contexts that were authentic, familiar, and grounded in their realities.

As indicated in Chapter 5, Teachers 4, 7, and 15 translated several of the interactional views articulated during SMIT'N into their inquiry-based classroom practices. Teacher 7 implemented her interactional views of inquiry-based teaching as an instructional mode wherein teachers need to (1) pose sincere questions, (2) avoid evaluating students' responses explicitly at the beginning of lessons, and (3) provide feedback that can encourage students to evaluate themselves. In contrast, Teacher 4 implemented her interactional views of inquiry-based instruction as requiring teachers to (1) avoid continuously repeating students' responses verbatim, (2) transcribe students' conceptions on the board without endorsing them, (3) avoid providing explicit evaluative comments early in the lessons, and (4) encourage students to pose and pursue sincere research questions. Finally, Teacher 15 implemented her interactional views of classroom inquiry as a form of instruction that requires teachers to (1) avoid affirming students' responses, (2) provide feedback that can enable students to evaluate themselves and draw connections, (3) use questioning for non-cognitive, social purposes, and (4) adopt polite directive behaviors.

The literature on teacher professional development provides evidence that improvements in teachers' views, understandings, and abilities related to inquiry-based science instruction do not always lead to significant changes' in teachers' actual classroom practices (Lee et al, 2004; Lotter et al, 2007; Wee et al, 2007). Several arguments have been made to explain why some programs succeed while others fail in influencing teachers' classroom practices. Supovitz and Turner (2000) emphasize that inquiry-based professional development programs that are connected to teachers' real classroom contexts, immerse teachers in inquiry, are intensive and sustained, and improve teachers' science content knowledge are more likely to have an impact on science teaching practices. In contrast, Luft (2001) provides evidence that participants' amount of teaching experience can be an important determining factor of the impact of in-service inquiry-based programs; her beginning teachers changed their beliefs more than their practices, whereas her experienced teachers changed their classroom practices more than their beliefs. Hogan and Berkowitz (2000) identify a variety of institutional barriers to change in classroom practices, including lack of time to plan and implement inquiry lessons, large class sizes, and students with weak learning abilities or behavioral problems. Likewise, Yerrick et al (1997) identify contextual constraints such as state-mandated requirements for coverage of a large number of science topics and excessive focus on student performance on standardized tests.

The fact that the interactional views that elementary teachers developed during SMIT'N seemed to guide their post-institute inquiry-based classroom practices can be explained based on the above arguments and perspectives on effective teacher professional development. First, the video-recorded inquiry lessons ensured that the SMIT'N institute remained connected to the teachers' classroom realities. Second, the institute provided teachers with numerous inquiry immersion experiences, improving teachers' science content knowledge and familiarity with inquiry processes. And, third, the SMIT'N teachers taught in a supportive institutional context; their school district had recently adopted FOSS, Full Option Science System (Lawrence Hall of Science, 2005), one of the most common kit-based curricula used to teach science through inquiry at the elementary level. As a result, both experienced and novice teachers seemed encouraged to translate such interactional views into improved inquiry-based teaching practices. At the time of the study, Teachers 7 and 15 were both beginning instructors (with less than three years of teaching experience) whereas Teacher 4 was considerably more experienced (with over

20 years of classroom experience). Nonetheless, all three teachers changed their inquiry-based classroom practices in ways that were consistent with their participation in the SMIT'N summer institute.

The Impact of SMIT'N on Teachers' Classroom Practices

In this section, I discuss the impact of the SMIT'N institute on elementary teachers' inquiry-based classroom practices. The discussion is divided into four main parts, focusing first on teachers' questioning behaviors, second on teachers' reactive behaviors, third on teachers' directive behaviors, and fourth on teachers' poetic behaviors.

Teachers' Questioning Behaviors

As described and illustrated in Chapter 5, after SMIT'N elementary teachers seemed to adopt more sincere or genuine questioning behaviors. Overall, Teachers 4, 7 and 15 tended to switch from asking display questions to posing sincere queries. More specifically, the three teachers' questions became (1) more student-centered, that is, more focused on students' thinking and articulation of their own ideas and individual experiences (as opposed to student recall of scientific words, shared classroom experiences and standard science concepts); and (2) more divergent or open-ended. Other changes in questioning behavior were unique to individual teachers. For instance, Teacher 7 resorted to an emphatic or marked intonation to create the impression that she was truly interested in students' responses to her questions. In contrast, Teacher 4 asked questions with hedges to encourage students to provide tentative or uncertain responses. Finally, Teacher 15 prefaced her questions with second-person and indefinite pronominal forms to encourage students to articulate their own thoughts and ideas. A summary of the linguistic changes associated with the three teachers' adoption of more sincere questioning behaviors is provided below (Table 6.4).

Table 6.4

Linguistic Features of Sincerity in Teachers' Questions

Features	**Display Questions**	**Sincere Questions**
Primary Focus	Student recall of scientific terminology; Student recall of shared classroom experiences; Student knowledge of standard scientific concepts	Student articulation of their own ideas and understandings; Students' individual and informal experiences; Student thinking and reasoning
Format	Yes-or-no questions; Convergent WH-questions	Prefaced yes-or-no questions; Open-ended WH-questions
Personal Pronouns	Absent; First-person pronouns (*I*- or *we*-questions)	*You*-questions; Indefinite pronominal forms (e.g., anybody)
Hedges	Absent	Plausibility shields (e.g., might, can, possibly)
Prefaces	Absent	"What do you think…?" "Does anybody know…?"
Intonation	Unmarked	Marked (emphatic tone)

Several analyses of classroom discourse have identified an apparent lack of sincerity in teachers' questions. Wellington & Osborne (2001) note that many of the queries that science teachers pose during classroom discussions are not real questions but in fact "*pseudo-questions*," that is, queries that appear to be open-ended but are actually closed because they encourage pupils to randomly guess the specific answer the teacher is thinking about. As a result, teachers and students engage in an interactional or linguistic game of "guess what's in my head." Similarly, Roth (1996) argues that teacher and textbook questions usually violate the fundamental assumptions of genuine information seeking behavior, namely that the speaker (1) does not know the answer to the question being asked, (2) has reason to believe that the listener can provide the answer, (3) is sincerely interested in learning the answer, and (4) believes the listener is willing to provide the answer. Furthermore, non-genuine teacher questions are usually focused on canonical discipline discourse and tend to encourage students to either guess or admit to their lack of knowledge. Rowland (2000) proposes that "classroom questions are not genuine requests for information, but public requests for display… in that the enquirer A [the teacher] already has the information sought in the question, and the request is for B [the student] to display whether or not s/he already has the information." The present study extends this literature on teacher questioning by identifying a set of very specific linguistic features that can potentially encourage students to perceive teachers' questions as lacking sincerity. As described above, linguistic insincerity is a discursive outcome closely related to the absence of hedges, *you*-prefaces, marked intonations, and open-endedness in teachers' questions, as well as a continued focus on shared classroom experiences, scientific terminology and standard science concepts. Awareness of such linguistic features can enable teachers to monitor, manage and even increase the sincerity levels of the oral questions they pose to students while facilitating classroom inquiries.

A number of science educators have emphasized the need for teachers to adopt student-centered questioning behaviors in inquiry-oriented learning environments. van Zee and Minstrell (1997b) argue that teachers need to employ "reflective toss," a type of oral questioning wherein the teacher continuously encourages students to be responsible for doing the thinking. In a different study, van Zee and Minstrell (1997a) emphasize that teachers and students need to engage in "reflective discourse," that is, extended series of questioning exchanges in which the teacher elicits, furthers, and guides student thinking by posing questions that encourage students to articulate their own thoughts and ideas. Likewise, van Zee et al (2001) propose that teachers can help students develop their conceptual understandings and construct scientific knowledge by asking questions that (1) elicit students' individual experiences, and (2) encourage students to derive more refined meanings from their own individual experiences. Based on these studies, it can be argued that the change in Teachers 4, 7 and 15's questions from being primarily focused on student recall of words and knowledge (pre-institute) to becoming more focused on students' ideas, thinking and individual experiences (post-institute) is consistent with what the specialized literature currently describes as effective inquiry-based questioning behaviors. In other words, the interactional views that the three SMIT'N teachers developed during the institute seemed to enable them to adopt inquiry-based questioning behaviors with the greater level of student-centeredness and reflectivity that discourse analysts in the field of science education have recently called for.

Previous research on mathematics classroom discourse has revealed that teachers tend to adopt more indirect or polite questioning behaviors while posing oral queries whose responses students might be unable to provide. Rowland (2000) analyzes the interactions between a primary school teacher who places five plastic "people" on the floor and then poses the question "*Right, Anna how many people are on the floor?*" Because the she is confident that her four-year-old pupil Anna will be able to provide an answer, the teacher asks her question blatantly. In contrast, her second question "*how many people <u>do you think</u> we need to make ten people?*" is asked in a more indirect way. Because she thinks her pupils might find her question challenging, the teacher resorts to a plausibility shield (the tentative verb *to think*). In other words, questions seen by the teacher as trivial are asked in a direct manner, whereas questions viewed as challenging are asked in a more indirect and polite manner. As a result, Rowland (2000) argues, the teacher is able to foster a "conjecturing classroom atmosphere," that is, a nonthreatening social context wherein students know that it is "all right to be wrong." Based on these findings and interpretations, it seems reasonable to propose that Teacher 4's post-institute tendency to pose questions with hedges had a similar interactional effect. By hedging, Teacher 4 rendered her questions more polite (i.e., less threatening to her students' face) and the post-institute whole-class discussion more conjectural (i.e., safer for students to offer tentative oral contributions).

Another important teacher questioning behavior that appeared to be connected to SMIT'N was Teacher 4's post-institute tendency to encourage her students to view their assigned task as authentic scientific inquiries by continuing to emphasize the need for students to pose and pursue research questions that met three "sincerity conditions," namely that students (1) were truly interested in learning the answer to the research question they would be investigating, (2) did not know the answer to the question in advance, and (3) would be able to experimentally answer their question within the allotted time using the materials available to them in the classroom. As described in Chapter 5, Teacher 4 usually checked the authenticity or sincerity of students' research questions by asking a series of *you*-questions with a yes-or-no format focused primarily on requesting honest confirmations from students.

The importance of the authenticity of students' research questions has been previously highlighted in the science education literature. Wells (1995) emphasizes that classroom inquiries need to be framed by "*real*" questions for students to effectively and productively develop new scientific understandings. Fundamentally, a real question expresses a student's desire to understand rather than a teacher's authoritative pronouncement of its importance. In Wells' own words "what makes a question real is the commitment of the questioner that energizes him or her to persist in efforts to make an answer to it, which he or she finds personally satisfying." When students pose real questions, their inquiry efforts are driven by a personal and honest desire to understand, thus leading to higher levels of student motivation and involvement. From this perspective, it can be argued that the sincerity conditions emphasized by Teacher 4 in her post-institute inquiry lesson served to ensure that student groups had a "real" research question to investigate, that is, that their classroom inquiries were motivated by a sincere or authentic desire to understand a particular aspect of crayfish behavior.

Teachers' Reactive Behaviors

After the SMIT'N summer institute, participating teachers tended to adopt less authoritative reactive behaviors, that is, to offer less authoritative discursive reactions to their students' oral contributions to inquiry-based classroom discourse. As pointed out in Chapter 5, Teacher 7 replaced her pre-institute explicit evaluations with verbatim repetitions that were implicitly evaluative in nature. In contrast, Teacher 4 replaced her implicitly evaluative verbatim repetitions with more neutral linguistic forms (reactive tokens, backchannels and hedges). Likewise, Teacher 15 substituted her implicitly evaluative reactive practices (both oral and written verbatim repetitions) with more neutral reactive strategies (nonverbal reactive tokens and hedges).

The above changes in inquiry-based teaching discourse provide evidence that the reactive behaviors adopted by teachers while interacting with students can be classified into different levels of discursive authority (Table 6.5). Teachers who explicitly point out whether their students' oral contributions are right or wrong establish the highest level of interactional authority possible (e.g., pre-institute Teacher 7). In contrast, teachers who avoid evaluating their students' contributions explicitly by offering verbatim repetitions or by skipping evaluative moves establish a medium level of discursive authority (e.g., post-institute Teacher 7, pre-institute Teacher 4, and pre-institute Teacher 15). Lastly, teachers who adopt a neutral stance toward their students' responses by strategically resorting to reactive tokens, backchannels, and hedges establish the lowest level of interactional authority possible (e.g., post-institute Teacher 4 and post-institute Teacher 15). In other words, comparisons between their pre- and post-institute interactional performances suggest that Teacher 7's authority level was reduced from high to medium, whereas Teachers 4 and 15's authority levels decreased from medium to low.

Table 6.5

Classification of Teachers' Reactive Strategies into Authority Levels

Relative Level of Authority	High	Medium	Low
Teachers' Reactive Strategies	Provision of explicit evaluative comments	Provision of implicit evaluative comments (verbatim repetitions) Skipping evaluative moves	Employment of neutral reactive tokens, backchannels and hedges (plausibility shields, attribution shields, etc.)

The authoritative interactional effects of teachers' reactive behaviors have been highlighted in previous analyses of classroom discourse in the fields of science and mathematics education (Forman & Ansell, 2002; Forman, Larreanmendy-Joerns, Stein, & Brown, 1998; Seymour & Lehrer, 2006; Strom, Kemeny, Lehrer, & Forman, 2001; Tabak & Baumgartner, 2004). This body of research draws heavily upon the concept of *revoicing*, a term originally coined by O'Connor and Michaels (1993) in reference to a discourse strategy in which elementary teachers reformulate their students' oral contributions to large-group discussions in ways that are more consistent with scientific and mathematic standard terminology. Revoicing moves are described as confirmation requests usually prefaced with the inference-making discourse marker "*so*" and the second-person pronoun "*you*," thus being addressed specifically to the student who just contributed to the discussion (e.g., "*so, what you mean is that…?*"). By rephrasing students' oral contributions in more sophisticated and specialized ways, O'Connor and Michaels argue, teachers lend authority to their students (i.e., add weight and force to pupils' contributions), at the same time allowing students to retain ownership over the more sophisticated and powerful reformulations. Forman et al (1998) provide a broader definition, arguing that "revoicing involves the reuttering of another person's speech through repetition, expansion, rephrasing, and reporting." Similarly, Seymour & Lehrer (2006) define revoicing as discourse tactics in which teachers repeat what a student says or expand students' utterances. In sharp contrast, Tabak & Baumgartner (2004) argue that repetition alone (as opposed to a reformulation of a student's contribution) does not constitute revoicing for it serves a legitimizing discursive function -- by repeating, the teacher sanctions a student statement as a legitimate contribution.

The findings of the present study inform the above debate over the interactional nature of revoicing. For instance, Teacher 15's post-institute strategy of providing neutral and informative feedback in response to her students' discursive contributions is fairly consistent with the notion of revoicing. By reformulating her students' contributions in more sophisticated and eloquent ways, Teacher 15 was able to share her authority with students. However, Teachers 4 and 7's verbatim repetitions of their students' responses do not constitute a form of revoicing. Rather than lending authority or empowering students, such repetitions served an implicitly evaluative discourse function. By claiming the superodinate interactional right to evaluate students' contributions implicitly, Teachers 4 and 7 asserted their own authority and power over the discussion. Therefore, it can be argued that the findings reported in the present study support Tabak & Baumgartner's (2004) argument that mere repetition of students' oral contributions does not constitute revoicing; such interactional effect necessarily requires reformulation on the part of the teacher.

Discourse analysts who adopt a sociolinguistic stance toward teachers' reactive behaviors tend to distinguish between minimal response tokens (i.e., backchannels that hearers use simply to display their attentive listenership to speakers) and substantive or more than minimal recipient behaviors (i.e., candidate understandings that serve not only to demonstrate attentiveness but also to check, clarify, expose and substantiate meanings and positions) (Farr, 2003; Oliveira et al, 2007a; Waring, 2002). As pointed out in Chapter 2, substantive recipiency is a prominent interactional feature of institutional discourse aimed primarily at developing understanding and constructing knowledge (e.g., classroom discussions), being infrequently employed by listeners in the context of everyday conversations. From this theoretical perspective, it can be argued that Teacher 15 switched from minimal to substantive recipient behavior (nonverbal token + candidate understanding) whereas Teachers 4 and 7 continued to display minimal recipient behaviors (verbatim repetitions, reactive tokens, backchannels or hedges without offering any candidate understandings) after participating in the SMIT'N institute.

Despite the above differences in terminology, a comparison of theoretical definitions and illustrative examples indicates that O'Connor and Michaels' (1993) notion of teacher revoicing is interactionally equivalent to the three substantive recipient behaviors described by Waring (2002), namely reformulating, extending and jargonizing. Nonetheless, it must be noticed that O'Connor and Michaels' (1993) theoretical perspective is more limited in the sense that it does not take into account the fact that, in addition to reformulations, teachers also make frequent use of minimal reactive behaviors that serve important and distinct interactional functions in classroom discourse. As pointed out in Chapter 5, after the summer institute, both Teachers 4 and 15 tended to adopt a neutral stance toward their students' responses by strategically incorporating nonverbal reactive tokens, backchannels and hedges into their reactive comments.

Furthermore, Teacher 7 was able to encourage her students to elaborate on their own ideas and to evaluate each other through strategic use of reactive tokens and backchannels. Such findings indicate that minimal reactive behaviors serve two very important interactional functions: (1) a means for teachers to avoid evaluating students' contributions (i.e., discursive neutrality function); and (2) a way for teachers to prolong or sustain interactions with students by maintaining an open channel of communication – phatic linguistic function (Jakobson, 1960).

The importance of discursive neutrality and phatic language has been highlighted in previous analyses of inquiry-based classroom discourse in the field of science education. van Zee and Minstrell (1997a; 1997b) described how a high school teacher was able to help students articulate their own beliefs and conceptions by (1) providing neutral acknowledgement of students' oral contributions (the teacher restated all student contributions even when they were not in agreement with standard scientific conceptions); and (2) encouraging students to keep talking through frequent use of conversational reactive expressions such as "*okay*," "*all right*," and "*uh huh*." Similarly, van Zee et al (2001) reported being able to encourage their students to explore different points of view and monitor their own thinking through neutral acknowledgment of students' discursive contributions (i.e., without signaling an evaluation of student utterances' correctness). Oliveira et al (2007a) described how a professor was able to help students articulate an explanation for how a candle works without validating it with his authority through the combined use of a set of non-evaluative reactive strategies: skipping reactive moves (IR sequences), using indirect quotations or attribution shields while referring to students' ideas, hedging (plausibility shields and vague commentary), and resorting to non-uptake (i.e., not incorporating information from students' preceding answers into his subsequent questions). These studies not only confirm that teachers' minimal recipient behaviors indeed serve important non-evaluative and phatic functions but also underscore neutrality as a crucial discursive feature of effective inquiry-based science teaching.

It is noteworthy that language scholars such as Labov (1972) and Tannen (1985) have argued that "evaluation" is an inherent and integral part of spoken discourse. Their argument is that, while participating in face-to-face verbal interaction, speakers inevitably convey particular evaluative attitudes toward the message and interlocutors through nonverbal cues such as pitch, tone of voice, prosodic shifts, speed, body posture, gestures, and facial expressions. In Tannen's (1985) own words "in speaking, everything that is said must be said in some way: at some pitch, in some tone of voice, at some speed, with some expression or lack of expression in the voice and on the face of the speaker… one cannot speak without showing one's attitude toward the message and the speech activity." From this perspective, it can be argued that discursive neutrality is unattainable since teachers inevitably convey evaluative attitudes while reacting to students' oral contributions, even when they choose not to verbalize or communicate their evaluations in an explicit manner to students. As pointed out in Chapter 4, Teacher 15 as well as other participants shared this view of inquiry-based science teaching as being unavoidably evaluative. Nevertheless, Teachers 4, 7 and 15's post-institute discursive performances indicate otherwise. As described in Chapter 5, both Teachers 4 and 15 were able to avoid evaluating and to adopt a neutral stance toward their students' contributions through skillful employment of reactive tokens, backchannels and hedges. Likewise, Teacher 7 was able to become less evaluative (or more neutral) by strategically blurring the inflectional demarcation of her implicit positive and negative evaluations. Such findings provide evidence that, even though absolute neutrality may be linguistically impossible, the interactional or social awareness that teachers developed during SMIT'N seemed to enable them to achieve a certain degree of neutrality in their interactions with students. By becoming less evaluative, teachers were able to facilitate inquiry science lessons that had less authoritative or asymmetric social structures.

Another important interactional issue recently raised in the science education literature is whether teachers' reactive behaviors constitute a form of Evaluation (i.e., E-moves) or Feedback (i.e., F-moves); two terms commonly used in reference to the third move in the triadic dialogue (Lemke, 1990). Tabak & Baumgartner (2004) and Wells (1993) argue that a clear distinction needs to be made between Evaluation and Feedback because the third move can serve only one of these two interactional functions separately, depending on whether teachers use it to evaluate students' contributions with respect to standard scientific conceptions or to offer new information to students. In contrast, Nystrand and Gamoran (1991) avoid the Evaluation-Feedback dichotomy, choosing instead to make a distinction between high-level Evaluations (occasions in which the teacher engages in uptake, building on what students have said) and low-level Evaluations (instances in which the teacher does not interact with students' contributions in any way except to evaluate them as right or wrong). It must be noticed that such a distinction is based on the following premises: (1) that teachers' reactive behaviors vary along an informative dimension (i.e., different informative levels are possible); and (2) that teachers' reactive behaviors are inherently evaluative (i.e., discursive neutrality is precluded as an interactional possibility). In contrast, Chin (2006) proposes a third classificatory system in which a distinction is made between four different types of teacher Feedback: affirmation-instruction, responsive questioning (neutral acceptance + follow-up questions), explicit correction-direct instruction, and constructive challenge (challenging question instead of explicit correction). This typology is based on two main premises: (1) that teachers' reactive behaviors vary along an evaluative dimension (i.e., different evaluative levels are possible, including neutrality), and (2) that teachers' reactive behaviors are inherently informative (even when teachers choose to pose follow-up questions instead of offering reactive comments). Combined, the above perspectives on teachers' reactive behaviors indicate that Evaluation and Feedback are not mutually exclusive interactional functions for they vary independently along two distinct dimensions: evaluative-neutral and informative-noninformative (Figure 6.12).

The findings of the present study support the proposed bidimensionality of teachers' reactive behaviors. As pointed out in Chapter 5, Teacher 15 stopped affirming her students' responses (pre-institute reactive behavior) and began to provide feedback (post-institute reactive behavior). In other words, Teacher 15's reactive behavior changed from the *Evaluation* quadrant to the *Evaluative Feedback* and *Neutral Feedback* quadrants (Figure 6.12). In contrast, Teacher 7 discontinued her pre-institute linguistic practice of providing explicit evaluations and replaced it with blurred verbatim repetitions. Therefore, it can be argued that Teacher 7 changed her reactive behavior from the *Evaluation* to *Acknowledgement*. Similarly, Teacher 4 switched from *Evaluation* (marked verbatim repetitions) to *Acknowledgement* (reactive tokens, backchannels, and hedges).

It must be noticed that asking follow-up questions is purposively excluded from the two-dimensional diagram proposed below (Figure 6.12). Such exclusion is consistent with the results of the present study which, as described in Chapter 5, showed that asking follow-up questions was a discursive strategy that Teacher 4 and 7 adopted to avoid offering negative evaluations to their students. By skipping the third move altogether, the two teachers were able to lower their authoritative status to intermediary levels (Table 6.4). Although such evasive discursive maneuver may implicitly convey negative evaluative information to students, it does not constitute the third move in a three-part teacher-student exchange. Instead, the follow-up question posed by the teacher initiates a new interactional sequence, thus leading to the occurrence of IR couplets (Oliveira et al, 2007a).

Figure 6.12

Two-dimensional diagram of teachers' third moves

EVALUATIVE DIMENSION

INFORMATIVE DIMENSION

EVALUATIVE FEEDBACK	NEUTRAL FEEDBACK
• Discursive features: informative and evaluative • Reactive behaviors: explicit evaluation + extension (highlighting significance, drawing connections, etc.)	• Discursive features: informative and neutral • Reactive behaviors: reformulation (revoicing), verbal token + candidate understanding
EVALUATION	**ACKNOWLEDGEMENT**
• Discursive features: non-informative and evaluative • Reactive behaviors: explicit evaluations, marked verbatim repetitions (affirmations)	• Discursive features: non-informative and neutral • Reactive behaviors: nonverbal tokens, backchannels, hedges, blurred verbatim repetitions

Teachers' Directive Behaviors

Teachers' employment of linguistic politeness seemed to remain for the most part unaffected by their participation in the SMIT'N summer institute. As described in Chapter 5, Teacher 7 gave a high number of polite commands during both the pre- and post-institute classroom inquiries, frequently resorting to declaratives, interrogatives, positive reinforcement, and polite formulae ("thank you," "excuse me" and "please"). In contrast, Teacher 4 tended to resort to politeness and indirectness while giving whole-class directives, often requesting physical displays of listenership and offering positive reinforcement to compliant students. Despite her tendency to give imperatives and direct commands to individual students and small groups, Teacher 4 did occasionally employ polite language (modal verbs, negative politeness, declaratives, interrogatives, and the marker “please”), and in one instance saved her student Spencer’s face by hedging rather than baldly correcting his view of scientific inquiry as being a mandatory process. Similarly, Teacher 15 also favored linguistic directness and impoliteness in her interactions with students, infrequently employing polite language such as affectionate comments, declaratives, and modal verbs. In one instance, Teacher 15 saved her ESL student Eric’s face by refraining from bluntly correcting his misuse of the word “bomb.”

Researchers of science, mathematics and social studies education have adopted different perspectives with regard to teachers’ employment of politeness in classroom discourse. van Zee and her collaborators have repeatedly argued that science teachers need to foster a respectful social environment to be able to effectively encourage students to engage in reflective classroom discourse and to help them better articulate their own beliefs and conceptions (van Zee & Minstrell 1997a; van Zee & Minstrell 1997b; van Zee et al, 2001). In their own words, “teachers should not provide immediate critiques of student thinking that possibly harbor alternative conceptions until a safe environment has been established” (van Zee & Minstrell, 1997b). Drawing on Brown and Levinson’s (1987) sociolinguistic theory of politeness, Rowland (2002) argues that teachers’ questions, evaluations and commands continuously pose threat to students’ face or sense of self-esteem. Moreover, teachers need to be polite and indirect in order to be able to teach fallibilistically (i.e., to invite conjectures from students despite the associated intellectual risks) and to create what Rowland (1999) calls a “Zone of Conjectural Neutrality” (a classroom social context in which conjectures are evaluated, not students). Similarly, Bills (2000) argue that politeness strategies or redressive action enable teachers to reduce the potential threat to students' face typically posed by communicative acts such as baldly correcting what students have said or done, imposingly providing students with instructions on what do next or how to proceed, and demanding explanation (which can be taken as an indirect correction or criticism by the student). Furthermore, through strategic use of politeness, teachers can reduce the teacher-student social distance, decrease the degree of imposition of face threatening acts (FTAs), and downgrade the power or authority differential that commonly characterizes teacher-student relationships. Because the ability to be polite to students is an essential part of effective and sensitive teaching, it can be argued that Teachers 4, 7 and 15's politeness strategies were indeed appropriate and beneficial to their students' inquiry-based science learning experiences.

In sharp contrast to the above researchers, White (1989) argues that, even though politeness enable elementary teachers to obtain students' cooperation and to create a safe social context in which to interact, such social goals should not take precedence over the construction of accurate academic knowledge. Overuse of positive politeness strategies by teachers (i.e., praising all student contributions, even when they are limited and mediocre), she argues, does not create a challenging social context for students. Instead, such form of politeness encourages students to focus exclusively on the obvious, leading to the co-construction of narrow academic knowledge. Likewise, the overuse of negative politeness by teachers (i.e., not correcting students when they offer an incorrect response) can lead to the co-construction of knowledge that is not only inaccurate and inappropriate but also lacking in academic rigor. In short, teachers should not prioritize interacting positively with students and saving students' face over academic accuracy and rigor. As White (1989) puts it "we must ask where to draw the line between social niceties for [classroom] management purposes and the deterioration of academic rigor."

From the above perspective, it could be argued that Teachers 4 and 15 crossed the line between politeness and academic rigor when they decided to save the two students' face and not correct their inaccurate contributions (Spencer's view of inquiry as mandatory, and Eric's misuse of the word "bomb"). However, Teacher 4 and 15's decisions not to evaluate their students should be understood with respect to the inquiry-based classroom context in which they were made. As pointed out in Chapter 5, both instances happened at the beginning of inquiry science lessons. So, instead of directly telling students that scientific inquiry does not follow a mandatory or fixed sequence of steps, Teacher 4 allowed them to experience the inquiry process and to find out for themselves. Similarly, it is unlikely that Eric's misuse of the word "bomb" would have had any substantial impact on the knowledge being constructed in Teacher 15's classroom. So, rather than offering a blatant correction or explicitly pointing out Eric's semantic mistake (which Eric could have perceived as a form of public humiliation), Teacher 15 opted for implicating or hinting at his minor semantic error, thus affording him a chance to recognize the problem on his own while continuing to participate in classroom interactions. Therefore, it can be concluded that Teacher 4 and 15's politeness strategies were indeed appropriate for their inquiry-based classroom contexts in which they were adopted.

As described in Chapter 5, after participating in the SMIT'N institute, Teacher 4's small-group directive behavior seemed to have changed. Before the institute, Teacher 4 gave only physical directives to student groups (i.e., requests for the performance of physical acts), focusing her commands exclusively on the students' performance of experimental procedures. In contrast, after the institute, Teacher 4 gave physical, cognitive and textual directives, urging student groups not only to perform particular procedures but also to reconsider certain information and to refer to certain texts (their lab reports). In other words, instead of focusing exclusively on student groups' experimental procedures, Teacher 4 also paid attention to their cognitive and writing activities.

Mathematics educators have researched how imperatives conventionally employed by mathematics teachers and textbooks writers position students in relation to the field of mathematics. Morgan (1996) argues such imperatives position students as capable members of a community of expert mathematicians, thus serving inclusive and inductive interactional functions. In contrast, Rotman (1988) and Herbel-Eisenmann (2007) distinguish between *inclusive* and *exclusive* imperatives. Inclusive imperatives encourage students to engage in mathematical thinking (i.e., to take on the role of thinkers) by instructing them to conduct cognitive actions that will afford them the right to be considered members of a community of mathematical experts (e.g., "consider," "define," "prove"). On the other hand, exclusive imperatives encourage students to take on the role of scribblers by encouraging them to engage in mechanical and procedural activity that can be excluded from the realm of mathematical expertise (e.g., "write," "calculate," "copy"), therefore failing to foster student membership in the mathematics community. These studies suggest that teachers' directive behaviors can serve to position students inclusively, that is, to encourage students to participate in classroom activity as legitimate members of particular expert communities.

Based on the above perspectives on directives, it can be argued that Teacher 4's small-group directive behavior became more inclusive after she participated in the SMIT'N institute. By directing student groups to think scientifically (i.e., to take on the role of scientific thinkers), Teacher 4 urged her students to go beyond procedural and mechanic aspects of scientific inquiry and to engage in cognitive activities that could potentially grant them rightful membership to a community of science experts. In other words, Teacher 4's cognitive directives interactionally positioned or marked students as legitimate science experts, thus encouraging them to conduct their classroom inquiries as “real” scientists (as opposed to merely following mechanical or experimental procedures imposed by a science expert such as the teacher or FOSS curriculum developer).

As indicated in Chapter 5, subsequent to the SMIT’N institute, other linguistic aspects of teachers’ directive behaviors also appeared to have changed, including their use of modal verbs and personal pronouns. The only exception was Teacher 7 who continued to employ authoritative and distancing “I/you” pairs while giving whole-class directives, and the solidarity-building pronoun “we” while giving directives to individual students. In contrast, Teacher 15’s directive behavior became less authoritative and distant after she discontinued her use of the distancing “you” and the mandatory modal “must” (pre-institute), and switched to the solidarity-building “we” and the more polite modal “would” (post-institute). Likewise, Teacher 4 became relatively closer and less authoritative after she stopped using only the distancing “you” (pre-institute) and began to also employ the inclusive “we” (post-institute) while giving directives to small groups.

A number of linguists and educational researchers have highlighted that the personal pronouns and modal verbs that writers use in their directives to readers serve as markers of relative social status and as a means for establishing particular types of social relationships. Hyland (2002) points out that the use of directives varies considerably across different genres of academic texts. In textbooks, writers tend to mark their authority status through more frequent use of “must” (which convey a strong sense of obligation on the reader). Furthermore, the reader tends to be identified explicitly as the person directed to act – frequent use of second-person pronouns (you) and first-person imperatives (*we will* or *let’s*). As a result, an authority structure is created in which readers are given a subordinate status. In sharp contrast, writers of research papers typically attempt to create a more egalitarian interpersonal context by using “should” instead of “must,” and by using impersonal directives such as imperatives and passive forms (to avoid explicit identification of the reader). Similarly, Oliveira et al (in press) describe how the authors of an environmental story meant to be read aloud by elementary teachers promote an asymmetric teacher-student relationship through the use of *you*-prefaced directives (both physical and cognitive) in which students are identified explicitly as the commanded party.

Herbel-Eisenmann (2007) describes how the absence of commands with first-person pronouns (both “I” and “we”) and prevalence of you-directives in a problem-based mathematics curriculum lead to the establishment of a distant and formal author-reader relationship in which the author remains in control of the common knowledge (Edwards & Mercer, 1987) in the classroom by recurrently telling students what to think and how to interpret their learning experiences. Morgan (1996) and Pimm (1987) point out that authors of mathematics textbooks sometimes use “we” authoritatively to associate themselves with a community of mathematics experts from which readers are excluded, and at other times inclusively to imply that the reader is also involved in and shares responsibility for mathematics activity. However, unlike other researchers who consider the pronoun “you” as interactionally distant, Morgan (1996) argues that “*you* may indicate a claim to a relatively close relationship between author and reader.”

The findings of the present study provide evidence that the personal pronouns and modal verbs that teachers use in their oral directives for the most part have the same interactional effects as pronoun and modals that writers employ in texts to direct their readers. In other words, such linguistic forms tend to establish similar commander-commanded relationships in both written and oral communicative modes. Nonetheless, some differences were noticeable. For instance, all of Teachers 4, 7 and 15's *we*-directives were inclusive. In other words, the three teachers did not associate themselves with science authorities while giving directives to students, choosing instead to continuously include their students and to share responsibility over scientific activity with them. Another difference was that the teachers' *you*-directives always seemed to have a distancing and authoritative effect, thus contradicting Morgan's (1996) suggestion that second-person pronouns can also foster close social relationships.

In addition to fostering student inclusiveness in classroom inquiries, teachers' directives also served to create and maintain student involvement in classroom discussions, an interactional function not identified in previous studies of teachers and writers' directive behaviors. As described in Chapter 5, Teachers 4, 7 and 15 gave poetic or involved directives (i.e., commands with figurative language and parallel repetitions) while facilitating their classroom inquiries. After participating in SMIT'N, Teacher 7's directives contained metonymies and synechdoches, whereas Teacher 15 interspersed her directives with sarcastic comments. In contrast, Teacher 4 made more extensive use of involved directives (both before and after the SMIT'N institute), employing a variety of poetic linguistic forms, including parallel repetitions and figures of speech (synechdoches, personifications, metaphors).

Researchers in the field of applied linguistics consider figures of speech and parallel repetitions as potential resources for spoken creativity (Carter, 2007; Swann & Maybin, 2007), arguing that such rhetorical devices serve a poetic communicative function (Jakobson, 1960). Carter (2004) proposes that creative language allows speakers to add an expressive contour to their utterances, enabling them to: engage listeners emotionally and affectively; foster intimacy (i.e., to establish interpersonal relations that are less formal and socially distant); express intensity (i.e., to attach stronger or weaker invested feelings and attitudes to their utterances);

and, express evaluation (i.e., to convey a positive or negative critical stance toward the content being uttered). Similarly, Boxer and Cortes-Conde (1997) describe how conversational interlocutors frequently employ creative, playful language as a means of displaying and negotiating social identities such as “a fun person to be with” and “a member of the group.” From this perspective, it can be argued that after their participation in the SMIT’N institute, elementary teachers adopted more creative directive behaviors. Such claim is supported by the more frequent and pervasive use of poetic directives by Teachers 4, 7 and 15 while facilitating their post-institute classroom inquiries. By directing in creative ways, the three teachers were able to engage their students affectively and emotionally, to assume less authoritative instructor identities, and to establish more intimate, conversational teacher-student interpersonal relations.

Teachers’ Poetic Behaviors

The three elementary teachers who participated in this study also adopted poetic behaviors while posing questions to students and while reacting to students’ responses. Teacher 7 made limited use of poetics, resorting to alliteration only once. In contrast, Teacher 4 employed a variety of figures of speech (exaggeration, metonymy, alliteration, onomatopoeia) and made frequent use of idiomatic expressions, and parallel repetitions. Similarly, Teacher 15’s poetic behavior was relatively frequent, usually taking the form of personifications, idiomatic expressions, and parallel repetitions (see Chapter 5).

Previous studies of classroom discourse have revealed that parallel repetitions constitute a potential resource that teachers have at their disposal for fostering student involvement in science discussions. Oliveira et al (2007a) describe how a professor uses parallel repetitions to skillfully draw students’ attention and intensify his negative assessment, fostering student emotional involvement by means of creating the interactional aura of a challenge. Oliveira et al (in press) provide an account of two elementary teachers who resort to parallel repetitions to reinforce and intensify their negative assessment of environmentally irresponsible behavior, to increase fourth graders' emotional involvement in discussions about ecological responsibility and moral ethics, and to increase students' levels of indignation and self-blame. Similarly, linguistic research on everyday conversations has highlighted the interpersonal significance of parallelism and repetitions. Tannen (1989), for example, argues that "repetition is a resource by which conversationalists together create a discourse, a relationship, and a world. It is the central linguistic meaning-making strategy, a limitless resource for individual creativity and interpersonal involvement." Carter (2004) proposes that repetitions of words and production of parallel structures allow speakers and listeners to creatively co-construct a greater level of interactional mutuality. The above findings and arguments are consistent with the findings of the present study which, as highlighted in Chapter 5, suggest that Teachers 4, 7 and 15 used oral parallelism and repetition for the purpose of fostering student involvement (i.e., to create a greater sense of interpersonal mutuality) in inquiry-based classroom discussions.

Previous research on classroom discourse has revealed that school teachers tend to use figurative language and idioms with a relatively high frequency. Lazar, Warr-Leper, Nicholson, and Johnson (1989) report that one out of ten utterances produced by K-8 teachers contain idiomatic expressions; idiom usage by teachers being more frequent at higher grade levels. Furthermore, K-8 teachers rarely employ similes, metaphors, and irony. Similarly, Kerbel and Grunwell (1997) note that primary school teachers tend to be unaware of their widespread employment of idioms in classroom settings (an average of 1.73 idioms per minute is reported). In both studies, it is argued that, rather than avoiding figurative language and idiomatic expressions, teachers need to become more aware of the idioms and figures of speech they frequently use in their classrooms, monitor their students' comprehension of such linguistic forms, and adjust their language to mach students' linguistic and cognitive abilities. Such findings are consistent with the results of the present study which, as described above, provides evidence that the two fourth-grade teachers (Teachers 4 and 15) did in fact employ figurative and idiomatic language more extensively and frequently than the kindergarten teacher (Teacher 7). The fact that students did not seem to be confused by teachers' figures of speech and idioms suggests that the three teachers were able to effectively adjust their language to a level that was comprehensible to their students; an outcome possibly related to the greater level of awareness that the teachers developed during the SMIT'N institute.

Implications

A grounded theory analysis of the SMIT'N summer institute revealed that participating elementary teachers became increasingly aware of the social or interactional implications of the language commonly used by instructors to teach science through inquiry. More specifically, teachers demonstrated an increased awareness of the authoritative functions served by discursive moves such as display questions, cued elicitation, convergent questioning, verbal cloze, affirmation, explicit evaluations of students' responses, verbatim repetitions, IRE triplets and IR couplets, second-person pronouns, "I/you" contrastive pairs, and impolite or direct directives. As a result, participants were gradually able to recognize that teacher talk is in fact multifunctional, serving not only cognitive ends (e.g., to scaffold student scientific thinking) but also important social functions (e.g., to avoid establishing asymmetric authority relations with students).

The above findings underscore the importance of increasing elementary teachers' levels of linguistic awareness, being consistent with previous studies of inquiry-based classroom discourse which have highlighted the need for science and mathematics teachers to become more aware of authority. Oliveira et al (2007a; 2007b) argue that science instructors need to develop a higher degree of "pragmatic awareness," that is, an improved comprehension of the language-mediated process underlying the enactment of authority in classroom encounters. This awareness, they argue, can enable science teachers to change their ways of talking as inquiry-based learning contexts demand, thus allowing them to better support their students' inquiry experiences. Amit and Fried (2005) describe how strong authority relationships can negatively interfere with students' engagement in mathematical thinking by promoting non-reflective forms of teacher-student interaction, and preventing students from participating in the construction of mathematical ideas. In authority-based classroom relations, students gain practice with obedience and teacher domination rather than negotiation and intellectual independence. To promote thoughtful and reflective learning of mathematics, teachers need to establish a relationship with students not based on authority but on intellectual partnership. The establishment of this type of relationship is contingent upon teachers' ability to share authority (i.e., to allow students to take part in the authority structure of the classroom without losing their own authority).

Based on the above arguments and findings, it can be argued that subsequent to the SMIT'N summer institute elementary teachers' demonstrated having developed increased levels of pragmatic awareness. Teachers' improved understandings of how authority is constructed in particular ways of talking about science enabled them to avoid always speaking authoritatively to students and to establish inquiry-based classroom relationships based on intellectual partnership. However, it must be emphasized that the SMIT'N teachers were not encouraged to completely remove authority from classroom discourse or to relinquish their authoritative status completely, but rather to use language with a greater awareness while facilitating inquiry lessons in their classrooms and to share authority with students. Not only is an authority-free stance toward inquiry-based discourse difficult (if not impossible) to achieve, but its educational value must be seriously questioned. Teachers need to maintain some degree of control or authority over the inquiry-based classroom discourse in order to ensure that students have productive and high-quality science learning experiences.

Researchers have adopted different theoretical perspectives with regard to the issue of teachers sharing authority with students. Bingham (2004) points out that the dominant view among educators is that “[authority] is something that one person [the teacher] has at the expense of another [the student]. To share authority, or to partake in the authority of another, is said to diminish ones’ autonomy, one’s freedom, and one’s maturity.” Those who hold such a view of educational authority tend to argue that sharing authority can make the teacher considerably weaker. In contrast, Oyler (1996) argues that teacher authority has a “content dimension” (i.e., the teacher has control over the knowledge that students are to learn or construct in the classroom, determining what constitutes true, legitimate and relevant information) and a “process dimension” (i.e., the teacher has control over the flow of talk in the classroom, following up on some ideas and dismissing others). When students are effectively encouraged to share authority, they start to take control of questioning and classroom discussions, over time also beginning to exert a level of control over the knowledge being constructed in the classroom. In other words, by sharing “process authority” teachers can encourage students to also share “content authority.”

The present study provides evidence that science teachers who share authority with students during classroom inquiries do not necessarily become weaker or experience a complete loss of authority. Furthermore, teachers can remain in control of classroom discussions and still be able to foster students' content authority through the adoption of student-centered questioning approaches and inclusive discursive strategies. By posing questions that students can answer based on their own personal experiences, teachers can position their students as complimentary experts, a role commonly found in collaborative research teams composed of experts with different areas of specialization (Jacoby & Gonzales, 1991). Rather than positioning students as novices (i.e., individuals who simply lack expertise), teachers can treat their students as complementary experts (i.e., individuals whose prior experiences confer them a certain level or degree of expertise that complements the teacher's scientific expertise). Furthermore, teachers' inclusive pronouns and directives can serve to legitimize students' oral contributions as well as their participation in classroom inquiries.

A comparative microethnographic analysis of SMIT'N participants' inquiry-based classroom practices revealed that after the institute elementary teachers demonstrated an increased ability to share authority with students by strategically adopting (1) teacher questioning behaviors that were relatively more student-centered, divergent, reflective, and sincere; (2) teacher reactive behaviors that were more neutral and informative; (3) teacher directive behaviors that were more polite, indirect and inclusive; and, (4) poetic behaviors that were more involved. Such findings underscore the relational or interactional nature of authority in educational contexts, being aligned with theoretical considerations and empirical results found in educational and linguistic research. Binghan (2004) highlights that educators have tended to treat and understand authority in individualistic and disconnected terms, that is, as something possessed or located solely in the hands of teachers. Such stance, she argues, neglects the fact that teachers and students are interactionally connected and actually take part in a relation of authority. In other words, authority is a relational and transactional construct jointly enacted or established as teachers and students interact. Similarly, applied linguists such as Jacoby and Gonzales (1991) argue that expert and novice are not static identities but dynamic and complex social statuses jointly achieved or constituted by participants in unfolding interaction. Rather than determined by a priori professional or institutional membership (e.g., a college degree), novice and expert status shift on a moment-to-moment basis; the same individual can be constituted as an expert in a given moment and reconstituted as a novice (or less expert) in the next, depending upon the topic under discussion, interlocutors, and other contextual factors. In short, these researchers emphasize that authority or expertise should be viewed as a form of social interaction rather than a static, unproblematic expression or reflection of a predetermined label.

The implication for teacher education raised by the above findings and arguments is that educators who set out to prepare teachers to effectively teach science through inquiry ought to go beyond the simple provision of static and ill-defined labels such as “guide” and “active inquirer” (Chapter 1). Not only do such labels have a limited informational value but they also encourage teachers to develop a nonrelational and static view of classroom inquiries, thus failing to foster deeper understandings of the dynamic and complex interactional processes that usually go on in the inquiry-based science classroom. As this study shows, a more effective approach is to equip elementary teachers with an improved understanding of questioning, reactive, directive, and poetic discursive behaviors that they can adopt while facilitating classroom inquiries in order to effectively enact “a guide on the side” and to foster teacher-student social relations that are consistent with inquiry-based models of science instruction.

Another important finding of this study was that post-institute teachers seemed more able to transfer expert interactional rights to elementary students, thus being consistent with current descriptions of inquiry-based science instruction (Chapter 1). This transfer was evident in the elementary teachers' post-institute tendency to relinquish, at least partially, the superordinate interactional rights to test students' knowledge through display questions, evaluate students' answers as being right or wrong, give direct or impolite directives, and employ detached language. Simultaneously, teachers encouraged students to take on the expert interactional rights to pose authentic questions, articulate their own thoughts and ideas, evaluate themselves, and interact with peers. Such a transfer of expert interactional rights, it was argued, led to the establishment of more symmetric and involved forms of teacher-student social relationship.

Perhaps the significance of this teacher-student transfer of expert interactional rights can be best understood in terms of the notion of *relative focus on interpersonal involvement*, a theoretical framework proposed by linguists to account for variations between different forms of discourse such as academic discussions and everyday conversations. Tannen (1985) proposes that different forms of discourse can be placed along an involvement-focused/message-focused continuum. Everyday conversations are typically involvement-focused in the sense that speakers employ discursive strategies that are more focused on interpersonal involvement (i.e., the expression of feelings, identities, and relationships) than on the message conveyed (i.e., accurately transmitting information). Conversely, academic discourse is characteristically message-focused in the sense that there is a relative lack of focus on interpersonal involvement and a stronger focus on information or message transmission. In other words, discourse types can be distinguished along the dimension associated with relative focus on involvement (or relative focus on message). Similarly, Tracy (1997) identifies the development of understandings and the establishment or maintenance of social relationships as competing goals of academic discourse. And, Carter (2004) argues that, in informal and non-institutional discourse, “the transfer of information is important but the creation of relationships is as significant.”

The finding that the SMIT’N teachers’ developed improved abilities to transfer expert interactional rights to students acquires a new significance when examined in terms of relative focus on involvement. This theoretical perspective enables us to recognize that traditional classroom discourse is message-focused. In such settings, the teacher employs discursive strategies focused primarily on the accurate transmission of scientific information; relating to students in effective ways is relatively unimportant. In contrast, inquiry-based classroom discourse is relatively less focused on conveying scientific information, consequently being more focused on the establishment of effective teacher-student interpersonal relations. Therefore, to be able to transition from traditional to inquiry-based science classroom discourse, teachers need to develop involvement-focused interactional strategies that can allow them to effectively relate to rather simply inform students; such a complex task requires teachers to be able to transfer expert interactional rights to their pupils. The SMIT’N participants’ improved abilities to transfer expert interactional rights to students provides evidence that teachers’ involvement-focused discursive strategies can be effectively developed through inquiry-based professional development programs that are explicit, reflective, authentic, and contextualized.

It will be convenient to end this section by making some recommendations for future professional development efforts. Given the strong and positive impact of the SMIT’N institute on teachers’ interactional views and practices, it is recommended that future inquiry-based programs continue of make use of guided, video-based discourse analysis. As pointed out in Chapter 3, careful and purposeful employment of such technology-mediated interventional format by professional developers can serve to (1) ensure that teacher education programs remain directly connected to participants' classroom realities, (2) foster collaboration among participants, and (3) provide participants with rich and realistic contexts for reflecting about science teaching and learning. Another recommendation is that professional developers adopt interventional formats that can effectively encourage teachers to develop deeper understandings of science instruction. Teachers should be encouraged to understand science instruction in its complexity rather than attempt to reduce it to oversimplified, generalized, and decontextualized practices and views that are likely to be of limited utility and instructional value. As described above, one effective way of developing teachers' educational understandings is to increase their familiarity with the specialized literature. Expert instruction on current research can provide teachers with a solid theoretical and empirical foundation on which to base their practices and views, thus making them more aware of and better able to manage particular aspects of science teaching.

Limitations

An important limitation of the present study is that it pays unequal attention to the teacher and student sides of inquiry-based teacher-student interaction. For the most part, its methods of data collection and analysis favored the teacher perspective on classroom discourse, paying relatively less attention to the student perspective. As described in Chapter 3, the video-recordings of inquiry science lessons were primarily focused on elementary teachers who were asked to wear a wireless lapel microphone. As a result, the videos contained more nonverbal information (face expressions, gestures, postures) about the teacher than her students. Likewise, the sounds captured with the wireless microphone contained detailed information about the linguistic features of teachers' utterances (e.g., their tone of voice, pitch, etc.), whereas the contents of students' statements were often difficult to hear due to interruptions, overlapping, and pupils' limited communicative skills. Furthermore, during the SMIT'N institute, elementary teachers were continuously encouraged to reflect about the interactional implications of the language used by teachers to address students engaged in classroom inquiries; only in a few instances teachers were asked to consider how students talked to teachers. Similarly, the comparative microethnographic analyses of pre- and post-institute inquiry science lessons tended to attribute the establishment of (a)symmetric social structures and relationships solely to teachers' discursive strategies, rarely emphasizing how students' discursive moves served to ratify or reject such social constructs. This apparent bias toward the teacher perspective is important for it promotes a unidirectional view of inquiry-based classroom discourse (from the teacher to her students) despite the actual bidirectionality of teacher-student interaction. As emphasized by Binghan and Sidorkin (2004), students do have agency within classroom relations and do react to teachers' authority, choosing to either accept it or reject it.

Another important limitation of the comparative microethnographic analyses of classroom discourse is the several contextual differences between pre- and post-institute inquiry science lessons. Because SMIT'N was offered during the summer of 2007, pre-institute inquiry lessons were recorded toward the end of the previous school year (Spring of 2007), whereas post-institute inquiry lessons were recorded at the beginning of the subsequent school year (Fall of 2007). As a result, each teacher was video-recorded while implementing pre- and post-institute inquiry science lessons with different groups of elementary students. Furthermore, because pre- and post-inquiry lessons were implemented at different parts of the school year, the science topics being discussed and investigated also differed. As indicated in Chapter 5, Teacher 7's pre-institute lesson was about the incubation of chicken eggs, whereas her post-institute lesson was on fabrics. Likewise, Teacher 4 implemented an inquiry lesson on electromagnets before SMIT'N, and an inquiry lesson on crayfish after SMIT'N. And, Teacher 15 implemented pre- and post-institute classroom investigations about roller coasters and go-carts, respectively. Such contextual differences in terms of the audience and investigative topic constitute an important limitation. As Jacoby and Gonzales (1991) point out, the establishment of expert-novice relationships is a highly contextualized language-mediated process; a person's interactional positioning can shift from expert to less-expert or to novice, depending on contextual factors such as the topic under discussion and interlocutors being addressed. Because pre- and post-institute inquiry lessons were not contextually identical, it becomes relatively difficult to estimate the extent to which the increased interactional symmetricality of post-institute lessons was due to contextual variations (e.g., different students and investigative topics) rather than the intervention itself (i.e., teachers' participation in SMIT'N). Nonetheless, the fact that post-institute classroom practices reflected specific views and understandings that the three elementary teachers developed during the summer institute constitutes compelling evidence that the observed changes in teachers' linguistic or interactional behaviors were indeed intervention-driven.

A third and final limitation of the present study is that teachers' emergent interactional views are characterized at group-level, whereas teachers' initial and final interactional views are described at the individual level. As described in Chapter 3, data for the grounded theory analysis of teachers' emergent interactional views came from video recordings of expert-facilitated discussions (i.e., morning expert instruction sessions and afternoon collaborative assessment sessions) as well as reflective reports written collaboratively by small groups of teachers. In contrast, data for the grounded theory analysis of teachers' initial and final interactional views originated from individual interviews and surveys. Because some teachers tended to participate in the expert-facilitated discussion sessions more than others, the grounded theory analysis of teachers' emergent interactional views became somewhat biased toward the more talkative teachers' interactional views. In other words, it is possible that the more reserved teachers held emergent interactional views that were distinct from those being expressed by teachers who participated more often in the SMIT'N discussions.

Future Research

The present study shows that exploring the interactional dimension of inquiry-based science instruction is well worth the effort and has lead to many useful insights. One particular area in need of further exploration is the student interactional perspective. As described in the previous section, more information is needed with regard to students' perceptions and understandings of the language used by teachers to talk about science. For instance, future research will have to clarify the extent to which teachers' poetic behaviors can potentially pose cognitive challenges to elementary students. Another issue is whether teacher discursive neutrality can indeed be a potential source of confusion for elementary students as argued by some SMIT'N teachers. Future research will also need to focus on the impact of teachers' discursive behaviors on students' inquiry-based science learning as well as students' views and attitudes toward science. For example, students' NOS and inquiry views can be assessed using instruments such as the Views of Nature of Science Questionnaire-Form VNOS-B (Views of Nature of Science Version B) (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002) and the VOSI-E (Views of Scientific Inquiry-Elementary School Version) instrument (Lederman & Ko, 2004). The combined use of such instruments and comparative discourse analyses is likely to enable researchers to determine whether elementary teachers can effectively encourage students to develop less authoritative views of science and scientific inquiry through the adoption of less authoritative inquiry-based interactional behaviors.

Another fertile ground for further research is the relationship between teachers' interactional views (i.e., their definitions of inquiry-based social roles and relationships) and discourse practices (i.e., communicative strategies teachers adopt while interacting with students engaged in classroom inquiries). The present study provides evidence that the interactional views teachers developed during SMIT'N indeed guided their post-institute inquiry-based discourse practices, however more research is needed to determine whether continued adoption of such discourse practices can overtime lead to changes in teachers' interactional views. The need for such research is highlighted by Richardson (1996) who proposes that "beliefs are thought to drive actions; however, experiences and reflection on action may [also] lead to changes in and/or additions to beliefs." Based on this argument, it seems plausible to expect teachers to gradually refine or hone their interactional views and discursive behaviors as they continue to engage in and reflect about their inquiry-based interactions with students.

Summary

The present study revealed that the SMIT'N summer institute indeed seemed to affect elementary teachers' interactional views and discursive practices. After participating in SMIT'N, not only did teachers perceive inquiry-based science instruction differently but they also altered their ways of interacting with elementary students during classroom inquiries. Overall, teachers developed increased levels of pragmatic awareness, being able to recognize the authoritative interactional functions served by discursive moves such as display questions, cued elicitation, convergent questioning, verbal cloze, affirmation, explicit evaluations of students' responses, verbatim repetitions, IRE triplets and IR couplets, second-person pronouns, "I/you" contrastive pairs, and impolite or direct directives. Furthermore, teachers demonstrated an improved ability to share authority and to transfer expert interactional rights to students by strategically adopting (1) teacher questioning behaviors that were relatively more student-centered, divergent, reflective, and sincere; (2) teacher reactive behaviors that were more neutral and informative; (3) teacher directive behaviors that were more polite, indirect and inclusive; and, (4) poetic behaviors that fostered more involvement. Such ability led to the establishment of more symmetric and involved teacher-student social relationships during the implementation of post-institute classroom inquiries.

The gradual shift in teachers' interactional views from a cognitive, monofunctional and decontextualized perspective to a social, multifunctional and contextualized conception of inquiry-based discourse as well as their post-institute translation of such emergent interactional views into actual classroom practices were considered evidence of the effectiveness of an explicit, reflective, authentic and contextualized approach to inquiry-based professional development. Despite its useful insights, the present study has limitations and future research efforts will need to be undertaken in order to further explore the student interactional perspective on classroom inquiries as well as the effects of teachers' continuous adoption of symmetric discursive practices on their interactional views. Such research efforts are likely to provide science educators with valuable and useful insights on how to effectively prepare teachers to engage in inquiry-based teacher-student interactions and use language in ways that can support their pupils' science learning experiences.

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Appendix A

Survey/Interview Guide: Teachers' Initial Interactional Views

Name: _________________________ **Date: ______________**

Survey: Initial Interactional Views

This is a survey about your inquiry science teaching practices. Below you will be asked to describe generally how you tend to interact with your students when you teach science through inquiry.

1. What is your role(s) as an instructor? Please, provide examples of previous interactions with your students that can illustrate your teaching role(s).

2. What are the role(s) of your students? Please, provide examples of previous interactions with your students that can illustrate their role(s).

3. What type of relationship(s) do you have with your students? Please provide examples of previous interactions that can illustrate this relationship.

4. How are these roles and relationships compared to occasions in which you use more traditional ways of teaching science such as lecturing?

5. Are there different types of roles and relationships in different moments of inquiry science lessons? If so, describe.

6. Which interactional skills do you consider to be your strengths and which ones do you consider to be your weaknesses when it comes to teaching science through inquiry? Please, explain.

7. Have you ever experienced any difficulty interacting or communicating with your students during inquiry science lessons? Please, explain.

8. What interactional or communicative skills do you think an elementary teacher needs to have in order to be successful in inquiry teaching?

Appendix B

Survey/Interview Guide: Teachers' Final Interactional Views

Name: _________________________ **Date: ______________**

Survey: Final Interactional Views

This survey will focus on whether and how your views of the interactional dimension of inquiry-based teaching were affected by your participation in the summer institute.

1. After participating in the workshop, do you view the interactions that you have with your students during science inquiry lessons in the same or different ways? Please, explain.

2. How do you now perceive the roles and relationship that you and your students have during inquiry science lessons?

3. During the workshop, did you become aware of any particular interactional skill that you did not know about before? If so, which ones?

4. What interactional skills do you now consider to be your strengths and weaknesses?

5. Do you think that what you learned about the many aspects of teacher-student interaction (e.g. questioning, responding, etc.) will help you improve your ability to teach science through inquiry? Why?

6. Of the many aspects of teacher-student interaction focused on in the workshop (questioning, responding, etc.), which ones do you think are the most important for an elementary teacher to become aware of? Explain.

7. Was there any particular aspect of teacher-student interaction that you considered to be irrelevant to your ability to teach science through inquiry? Explain.

8. Was there any important interactional skill or aspect of teacher-student interaction that was not addressed in the workshop? Explain.

9. Was there any particular interactional skill or aspect of teacher-student interaction that you would like to learn more about during the school-year workshops? If so, which ones?

Appendix C

Informed Consent Forms

Study #07-11758

INDIANA UNIVERSITY - BLOOMINGTON
INFORMED CONSENT STATEMENT
Discourse-focused professional development for elementary teachers

You are invited to participate in a research study. The purpose of this study is to learn how to better prepare elementary science teachers to communicate effectively with students during inquiry-based instruction. As participants, you will be video-recorded while teaching an inquiry-based science lesson in your classroom. You will then be invited to attend a review session to comment on your own tape. Segments of your videotape will be shared and discussed during the 2007 SMIT'N summer institute in order to illustrate particular communicative abilities (e.g. questioning, responding, etc). After the summer institute, you will be video-recorded in your classroom for a second time, and be invited to attend a second review session to comment on potential changes in your communicative abilities. Both review sessions will be audio-recorded. No information concerning your teaching performance will be released to other school personnel.

INFORMATION
In the Spring '07, elementary teachers attending the 2007 SMIT'N Summer Institute will be participating in this study. Participation will require that you allow the researcher to video-record the implementation of two inquiry-based lesson plans in your classroom (one lesson prior and another one after attending the summer institute). You will also be asked to attend two review sessions to comment on your teaching performance. Finally, you will be asked to allow the researcher to share segments of your videotape with other elementary teachers during the summer institute. The summer institute will also be videotaped. All video and audiotapes will be collected by the researcher.

RISKS
There are no foreseeable risks associated with your participation in the study.

BENEFITS
Knowing how to prepare elementary science teachers to communicate effectively with their students while engaged in inquiry-oriented instruction is important. This type of knowledge can be used to guide teacher educators to better prepare future science teachers. Furthermore, you may find the learning experience enjoyable and the information helpful to your future teaching practice.

CONFIDENTIALITY
In order to preserve confidentiality, a coding system will be used. Each participating teacher will be assigned a pseudonym. A key will be constructed that will indicate the identity of each participant. This way there will be no link back to your real identity. The key containing the participants' identities will be safely kept by the researchers. No information concerning the individuals' identity will be included in reports. All audio and video recordings along with the key list will be destroyed by December 2008.

CONTACT
If you have questions at any time about the study or the procedures, you may contact the researcher, Alan Oliveira, at Education Building R. 3111, 856-8117 and aoliveir@indiana.edu.

If you feel you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the office for the Human Subjects Committee, Carmichael Center, L03, 530 E. Kirkwood, Bloomington, IN 47408, 812/855-3067, or by e-mail at iub_hsc@indiana.edu.

____
Teacher's initials

PARTICIPATION

Your participation in this study is voluntary; you may refuse to participate without penalty. If you decide to participate, you may withdraw from the study at anytime without penalty and without loss of benefits to which you are otherwise entitled. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed.

CONSENT

I have read this form and received a copy of it. I had all my questions answered to my satisfaction.

Teacher's signature____Date___________

Investigator's signature_____________________________________ Date___________

Informed consent date: 02/26/07

Page 2 of 2

IRB Approved
Approval Date: MAR 0 1 2007
Expires: MAR 0 1 2008

Study #07-11758

INDIANA UNIVERSITY - BLOOMINGTON
INFORMED CONSENT STATEMENT
Discourse-focused professional development for elementary teachers

Your child is invited to participate in a research study. The purpose of this study is to learn how to better prepare elementary teachers to communicate effectively with students during inquiry-based science instruction. Your child's teacher will be video-recorded while teaching two inquiry-based science lessons in your child's classroom. As a participant, your child and other students in his/her classroom may be incidentally video-recorded while talking to the teacher. These activities are part of their regular curriculum. Your child's grade will not be affected by this study, nor will any information concerning his/her personal or group performance be released to your instructor or other classmates.

INFORMATION
In the Spring and Fall '07, elementary teachers and students will be participating in this study. Participation will require that you allow the researcher to video-record your child during the implementation of two inquiry-based lesson plans in your child's classroom. Although the video-camera will be mostly focused on the teacher, who will be wearing a wireless microphone, your child may also be incidentally recorded while talking to the teacher. The videotape will be watched and commented on by the teacher and the researcher in two review sessions. Furthermore, you will be asked to allow the researcher to share segments of the videotape with other elementary teachers during a summer institute called SMIT'N, which will take place at Indiana University in June of 2007.

RISKS
There are no foreseeable risks associated with your child's participation in the study.

BENEFITS
Knowing how to prepare elementary science teachers to communicate effectively with their students while engaged in inquiry-oriented instruction is important for this type of knowledge can be used to guide teacher educators to better prepare future science teachers.

CONFIDENTIALITY
Measures will be taken to preserve confidentiality. First, video-recordings will be made from the back of the classroom in order to avoid recording your child's face. Furthermore, a coding system will be used. Second, your child will be assigned a pseudonym. A key will be constructed that will indicate the identity of each student. This way there will be no link back to your child's real identity. The key containing the students' identities will be safely kept by the researchers and will be destroyed by December 2008. No information concerning the students' identity will be included in reports. All video and audio recordings will be destroyed by December 2008.

CONTACT
If you or your child has questions at any time about the study or the procedures, you may contact the researcher, Alan Oliveira, at Education Building R. 3002, 856-8118 ext. 36340 and aoliveir@indiana.edu.

If you or your child feels you have not been treated according to the descriptions in this form, or your rights as a participant in research have been violated during the course of this project, you may contact the office for the Human Subjects Committee, Carmichael Center, L03, 530 E. Kirkwood, Bloomington, IN 47408, 812/855-3067, or by e-mail at iub_hsc@indiana.edu.

__________ Parent's initials   __________ Student's initials

PARTICIPATION
Your child's participation in this study is voluntary; he/she may refuse to participate without penalty. If your child decides to participate, he/she may withdraw from the study at anytime without penalty and without loss of benefits to which you are otherwise entitled. If your child withdraws from the study before data collection is completed your data will be destroyed. Parents that do not whish to have their child's data used will have their request honored.

CONSENT
I have read this form and received a copy of it. I had all my questions answered to my satisfaction.

I agree to allow my child, ____, to take part in this study.

Parent's signature____ Date__________

Student's signature____ Date__________
(students 9 years of age and older)

Investigator's signature____________________________________ Date__________

Informed consent date: 02/26/07

IRB Approved
Approval Date: MAR 0 1 2007
Expires: MAR 0 1 2008

Recruitment Script (to be read aloud to elementary students)

Hello, my name is Alan Oliveira. I am here to request your participation in a study that I am doing. The purpose of this study is to learn how elementary teachers can communicate well with students while teaching science. Your teacher will be video-recorded while teaching two science lessons in your classroom. Although the video-camera will be mostly focused on your teacher, who will be wearing a wireless microphone, you may also be recorded while talking to the teacher. The science lessons are part of your regular classroom activities. Your grade will not be affected by this study, nor will any information about you be given to your instructor or other classmates.

I am passing out the informed consent statement for you and your parents to read and sign. Even if one of your parents sign the informed consent statement, if you do not wish to participate then you do not have to. All you need to do is tell me. Does anyone have any questions?

Appendix D

Curriculum Vita

Curriculum Vitae

Alandeom Wanderlei de Oliveira
Department of Curriculum and Instruction
Indiana University
Campus: Bloomington
Office: W. W. Wright School of Education, room 3111
Title: Doctoral Candidate
Beginning semester: Fall 2003
Email: aoliveir@indiana.edu

EDUCATION

2002	MNS	Southeast Missouri State University, Cape Girardeau, MO Science Education
1997	B.S.	Goias Federal University, Goiania, GO, Brazil Chemistry

HONORS/AWARDS

2008 Distinguished Paper Award for the best publication in Cultural Studies of Science Education during the Year 2007.

2004 Clyde and Bessie L. Lineback Fellowship at Honors Day, Indiana University.

2002 "Certificate of Academic Distinction" for academic excellence in Graduate Studies, Southeast Missouri State University.

1998 Steven's Summer Research Assistantship, Chemistry Department, University of Missouri-Columbia.

PROFESSIONAL WORK EXPERIENCE

2007- 2007 **Instructor, Saturday Science,**
Indiana University, Bloomington, IN

Fall 2007 Taught a course entitled "Food Science" to 3rd and 4th graders.

2007- present **Research Assistant, Science Education,**
Indiana University, Bloomington, IN

Summer 2007 Coordinated an inquiry-based summer institute for in-service elementary teachers. Facilitated instruction and discussion sessions focused on classroom language and teacher-student interaction.

Fall 2007 Coordinated school-year, follow-up meetings, provide in-service elementary teachers with classroom support, video-record teachers' implementation of inquiry science lessons, and conduct data analysis.

2007- 2007 **Instructor, Saturday Science,**
Indiana University, Bloomington, IN

Spring 2007 Taught a course entitled "Chemistry Magic" to 3rd and 4th graders.

2006- 2007 **Research Assistant, Science Education,**
Indiana University, Bloomington, IN

Fall 2006–Spring 2007 Assisted faculty members with writing of research grants, applications for human subjects committee, video-recording of classes, and data analysis.

2004- 2007 **Tutor, Mathematics,**
Indiana University, Bloomington, IN

Fall 2004–Spring 2007 Taught SAT mathematics to ESL High School students from Angola.

2003- 2006 **Assistant Instructor, Science Education,**
Indiana University, Bloomington, IN

Fall 2003–Spring 2006 Taught undergraduate level introduction to scientific inquiry course for pre-service elementary teachers. Taught undergraduate level science methods courses for pre-service elementary teachers.

<u>Courses Taught All Undergraduate Level</u>
Science in the Elementary School
Introduction to Scientific Inquiry

2003-2003 **Assistant Instructor, Mathematics Education**
Goias State University, Jussara, GO, Brazil.

January-July Taught undergraduate level mathematics courses for preservice secondary teachers. Taught undergraduate level mathematics methods courses for inservice elementary teachers.

<u>Courses Taught All Undergraduate Level</u>
Plane Geometry
Space Geometry
Functions for Complex Numbers
History of Mathematics
Elements of Mathematics

Financial Mathematics
Probability and Statistics
Teaching Mathematics at the Elementary School
Algebra for Elementary and Secondary Teachers

2001-2002 **Teaching Assistant, Science Education**
Southeast Missouri State University, Cape Girardeau, MO.

Fall 2001-Fall 2002 Taught undergraduate level introduction to scientific inquiry course for preservice elementary teachers.

Courses Taught All Undergraduate Level
Introduction to the Process of Science for Elementary Teachers

2001-2002 **Webmaster, Science Education**
Southeast Missouri State University, Cape Girardeau, MO

Fall 2001-Spring 2002: Created and maintained a professional development website: http://cstl-csm.semo.edu/biocases/ english/english_intro.htm

2000-2001 **Assistant Instructor, Biology and Chemistry Education**
Goias State University, Jussara and Ipora, GO, Brazil.

January-July Taught undergraduate level biology courses for pre-service secondary teachers. Taught undergraduate level mathematics courses for pre-service secondary teachers. Taught undergraduate level chemistry courses for pre-service secondary teachers. Taught undergraduate level physics courses for pre-service secondary teachers.

Courses Taught All Undergraduate Level
Human Physiology
Biostatistics
Plane Geometry
Space Geometry
Biochemistry
General Chemistry
Physics I - Mechanics
Physics II – Electricity

2000-2001 **Tutor, English as a Second Language**
Cultura Americana (private language school), Jussara, GO, Brazil.

January-July Taught English as a Second Language to middle- and high-school students.

1998-1999 **Research Assistant, Protein Crystallography**

University of Missouri, Columbia, MO

Fall 1998-Fall 1999: Performed protein purification in a FPLC system, searched for crystallization conditions of proteins, collected data in x-ray diffractometer under cryogenic conditions, solved protein structures by using Denzo, Scalepack and Xplor programs, collected data at Synchrotron in the Brookhaven National Lab, trained new graduate students, maintained lab equipment and ordered chemicals.

1998-1998 **Teaching Assistant, Chemistry**
University of Missouri, Columbia, MO

Spring 1998 Taught a general chemistry laboratory course to undergraduate students.

<u>Courses Taught All Undergraduate Level</u>
General Chemistry

1997-1997 **Teacher, Physics**
Colegio Objectivo (private school), Jussara, GO, Brazil

February-June Taught high school level physics to senior high school students.

1996-1996 **Intern, Gasoline Quality Control**
MERCOIL **–** Oil Distributor Ltd, GO, Brazil.

March-September: Visited gas stations to perform quality control tests on various fuels (oil derivatives and alcohol), recorded field-test results and forwarded reports to central base.

1995-1996 **Research Assistant, Medicinal Plants**
Goias Federal University, Goiania, GO, Brazil

March 1995-September 1996: Searched for medicinal plants with therapeutic potential, extracted and isolated plant compounds (chromatographic techniques), and tested bioactivity on bacterial colonies.

1995-1995 **Teaching Assistant, Chemistry**
Goias Federal University, Goiania, GO, Brazil

August-December: Assisted professor with the preparation of organic chemistry labs and held office hours for undergraduate nursing students.

<u>PUBLICATIONS</u>

Oliveira, A. W. & Dhingra, K. (in press). Experiencing science education in the US: The international graduate student perspective. *Cultural Studies of Science Education*.

Oliveira, A. W., Colak, H., & Akerson, V. L. (in press). "Who polluted the Potomac?" The translation and implementation of a US environmental story in Brazilian and Turkish classrooms. *Cultural Studies of Science Education*.

Oliveira, A. W., Colak, H., & Akerson, V. L. (in press). Curriculum translation and environmental education: Considering issues of discursive intentionality, interpretation, and validity. *Cultural Studies of Science Education*.

Oliveira, A.W., & Sadler, T.D. (2008). Interactive patterns and conceptual convergence during student collaborations in science. *Journal of Research in Science Teaching*, 45(5), 634-658.

Pongsanon, K., Oliveira, A. W., Akerson, V. L., & Colak, H. (2008). Getting the Big Picture: The Impact of a Summer Workshop on Teachers' Views of Scientific Inquiry, Nature of Science and Classroom Interaction. *NARST Conference Proceedings*.

Oliveira, A.W., Sadler, T.D., & Suslak, D.F. (2007). The linguistic construction of expert identity in professor-student discussions of science. *Cultural Studies of Science Education*, 2(1), 119-150.

Oliveira, A., Sadler, T., & Suslak, D. (2007). Analyzing language, interaction and outcomes in an inquiry-oriented classroom. *Cultural Studies of Science Education, 2*(1), 165-170.

Hanson, D.L., Akerson, V.L., Donelly, L., Tira, P., Townsend, J.S., White, O., Oliveira, A.W., Colak, H., & Genel, A. (2006). *SMIT'N – A collaborative approach to grant writing and professional development*. ASTE Conference Proceedings.

Oliveira, A.W., & Sadler, T.D. (2006). *Interactive patterns and convergence of meanings during student collaborations in science.* NARST Conference Proceedings.

GRANTS FUNDED

2007 Awarded $4000 from a competition for summer research funds (E Wayne Gross Fund) to conduct a project entitled "Regulative discourse during the implementation of environmental curricula in a Brazilian elementary classroom," Indiana University, May.

2006 Awarded $4000 from a competition for summer research funds (E Wayne Gross Fund) to conduct a project entitled "Who polluted the Potomac? – a comparative account of culturally-sensitive and situated instruction", Indiana University, May.

2006 Awarded $500 from a competition for traveling funds to attend the National Association for Research in Science Teaching, Curriculum & Instruction Department, Indiana University, April.

2005-2008 Akerson, V.L., Bonner, J., & Schick, J. & Q612 Graduate Students “Scientific Modeling for Inquiring Teachers Network (SMIT’N).” Indiana State Department of Education Math and Science Partnership Program. $290,399.

2005 Awarded $3000 from a competition for summer research funds (E Wayne Gross Fund) to conduct a project entitled “Understandings and cognitive processes in students’ collaborative approaches to scientific inquiry”, Indiana University, May.

2004 Awarded $1500 from a competition for summer research funds (E Wayne Gross Fund) to conduct a project entitled “Interactive patterns and convergence of meaning during student collaborations in science”, Indiana University, May.

1998 Awarded $3000 Steven’s Summer Research Assistantship to conduct a project entitled “Structural determination of human GAPDH”.

PRESENTATIONS

Pongsanon, K., Oliveira, A. W., Akerson, V. L., Colak, H., & Genel, A. (2008, April). *Getting the Big Picture: The Impact of a Summer Workshop on Teachers’ Views of Scientific Inquiry, Nature of Science and Classroom Interaction.* Paper presented at the annual meeting of National Association for Research in Science Teaching, Baltimore, MD.

Oliveira, A. W., Colak, H., & Akerson, V. L. (2008, April). *"Who Polluted the Potomac? The Translation and Implementation of an Environmental Story in Brazilian and Turkish Elementary Classrooms*. Paper presented at the annual meeting of National Association for Research in Science Teaching, Baltimore, MD.

Oliveira, A.W. (2008, March). *Multilingual Curriculum Implementation: Exploring the Impact of Translation on Environmental Instruction*. Paper presented at the 2008 Indiana University Science Education Research Symposium, Bloomington, IN.

Pongsanon, K., Oliveira, A. W., Akerson, V. L., Colak, H., & Genel, A. (2008, March). *Getting the Big Picture: The Impact of a Summer Workshop on Teachers’ Views of Scientific Inquiry, Nature of Science and Classroom Interaction.* Paper presented at the 2008 Indiana University Science Education Research Symposium, Bloomington, IN.

Oliveira, A.W., Donnelly, L., Akerson, V., Colak, H., & Pongsanon K. (2008, January). *Teacher-Student Interaction: Drawing Connections among Classroom Discourse, Scientific Inquiry, and Explicit NOS Instruction*. Three-hour workshop presented at the 2008 International Meeting of the Association for Science Teacher Education, Saint Louis, MO.

Oliveira, A.W., & Sadler, T.D. (2007, April). *The linguistic construction of expert identity in teacher-student discussions of science*. Poster presented at the annual meeting of National Association for Research in Science Teaching, New Orleans, LA.

Oliveira, A.W., & Suslak, D.F. (2007, March). *Analyzing language, interaction and outcomes in an inquiry-based classroom*. Paper presented at the 2007 Indiana University Science Education Research Symposium, Bloomington, IN.

Oliveira, A.W. (2007, February). *Curriculum translation and the development of environmental awareness among Brazilian and Turkish elementary students*. Paper presented at the 2007 Indiana University Science Education Brown Bag Series, Bloomington, IN.

Oliveira, A.W., & Sadler, T.D. (2006, April). *Interactive patterns and convergence of meanings during student collaborations in science.* Paper presented at the annual meeting of National Association for Research in Science Teaching, San Francisco, CA.

Oliveira, A.W. (2006, March). *The linguistic construction of expert identity in teacher-student discussions of science*. Paper presented at the 2005 Indiana University Science Education Research Symposium, Bloomington, IN.

Oliveira, A.W. (2006, March). *The linguistic construction of expert identity in teacher-student discussions of science*. Invited lecture at the University of Florida, Gainsville, FL.

Phillipson-Mower, T., Townsend, S., White, O., & Oliveira, A.W. (2006, February). *Make connections with environmental education.* Oral presentation at Hoosier Association of Science Teachers, Inc. (HASTI), Indianapolis, IN.

Oliveira, A.W. (2005, March). *Interactive patterns and convergence of meanings during student collaborations in science.* Paper presented at the 2005 Indiana University Science Education Research Symposium, Bloomington, IN.

Oliveira, A.W. (2004, July). *Teaching chemistry via investigative cases*. Six-hour workshop offered during the XII National Meeting of Chemistry Students/XIII Midwest Meeting of Debates about Chemistry Teaching, Goiania, Brazil.

Oliveira, A.W. (2004, February). *Investigative case-based learning (ICBL), not your usual high school science.* Oral presentation at Hoosier Association of Science Teachers, Inc. (HASTI), Indianapolis, IN.

Oliveira, A.W. (2003, June). *Colloquial English*. Five-hour workshop offered during the IV Pedagogical Week of Goias State University, Brazil.

Waterman, M.A., Stanley, E.D., Oliveira A.W., & DeSantos, V. (2003, January). *Implementing case-based learning with Brazilian high school and U.S. college teachers*. Association for the Education of Teachers of Science. St. Louis, MO.

Oliveira, A.W. (2002, June). *A fungus with a mission*. Oral presentation at BioQUEST Workshop, Beloit, WI.

Oliveira, A.W., DeSouza, V. (2002, May). *Using LifeLines cases in the classroom*. Oral presentation at LifeLines Online Workshop, Cape Girardeau, MO.

Oliveira, A.W., DeSouza, V. (2001, August-December). *Biology case-based learning in Brazilian high schools*. Professional Development Workshop offered to pre and in-service high school biology teachers, Goias State University, Ipora, GO, Brazil.

Oliveira, A.W. (2000, June). *Determination of protein structures*. Five-hour workshop offered at Goias State University, Brazil.

Oliveira, A.W. (1996, September). *Phytochemical study of Pyrostegia venusta Myers*. IV Internal Seminary of Scientific Initiation/CNPq, Goiania, GO, Brazil.

SERVICE for JOURNALS

Reviewer, *Journal of Research in Science Teaching* (2007 - present)
Responsibilities included reviewing research manuscripts submitted for publication in *Journal of Research in Science Teaching* in the field of science education.

Reviewer, *School Science and Mathematics* (2006 - present)
Responsibilities included reviewing research manuscripts submitted for publication in *School Science and Mathematics Journal* in the field of science education.

SERVICE for PROFESSIONAL ORGANIZATIONS

Presider, National Association for Research in Science Teaching, Baltimore, MD, (2008).

Reviewer, Strand 2, Learning: Contexts ,Characteristics and Interactions. National Association of Research in Science Teaching, Baltimore, MD (2008).

Reviewer, Session Thread – Student learning: Issues related to Pre-K-12 student learning of science. The Association for Science Teacher Education, Saint Louis, MO (2008).

Presider, National Association for Research in Science Teaching, New Orleans, LA, (2007).

Reviewer, Strand 2, Learning: Contexts ,Characteristics and Interactions. National Association of Research in Science Teaching, New Orleans, LA (2007).

Member of Organizing Committee, *VII Midwest Meeting of Debates about Chemistry Teaching*, Goiania, Brazil (1995)

Member of Organizing Committee, *XII National Meeting of Chemistry Students*, Goiania, Brazil (1994)

SERVICE for DEPARTMENT, COLLEGE & UNIVERSITY

Served on Search Committee for Indiana University Science Education/Science Assistant Professor (2008)

Organized the 2007 Indiana University Science Education Research Symposium, Indiana University, Bloomington, IN.

Served on Search Committee for Indiana University Science Education/Biology Associate Professor (2007)

Served as Chair of Election Committee, Goias State University, Jussara, GO, Brazil (2003)

PROFESSIONAL AFFILIATIONS

The Association for Science Teacher Education
National Association for Research in Science Teaching
National Science Teacher Association
School Science and Mathematics Association